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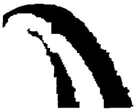

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CHAS. N. GOULD, Director.
L. L. HUTCHISON, Assistant Director.

Circular No. 1

THE OKLAHOMA GEOLOGICAL SURVEY
ITS ORIGIN, SCOPE AND PURPOSE

Norman, Okla., October 1908.

Democrat-Topic Print

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Circular No. 1

THE OKLAHOMA GEOLOGICAL SURVEY
ITS ORIGIN, SCOPE AND PURPOSE

Norman, Okla., October 1908.
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THE AUTHORITY.

ity for the establishment of the Geological Sur-
ed in Section 37 of Article 5, of the Constitution
which reads as follows.

slature shall provide for the establishment of a State
Geological and Economic Survey.

THE LAW.

The Survey was established by the first legislature of Oklahoma. The bill providing for its establishment, was introduced by Senator R. E. Stafford. The bill follows:

SENATE BILL NUMBER 75.

An Act.

TO AUTHORIZE A GEOLOGICAL SURVEY OF THE STATE, PROVIDE FOR A GEOLOGICAL COMMISSION, AND DEFINE THE POWERS AND DUTIES OF THE SAME. BE IT ENACTED BY THE PEOPLE OF THE STATE OF OKLAHOMA:

Section 1. There is hereby created a bureau, to be known as the "Oklahoma Geological Survey," which shall be under the direction of a commission, to be known as the State Geological Commission, composed of the Governor, the President of the State University, and the State Superintendent of Public Instruction.

Sec. 2. The said Commission shall serve without compensation, but shall be reimbursed for actual and necessary expenses incurred in the performance of their official duties, said Commission shall have general charge of the bureau, and shall appoint as director of the survey, a geologist of established reputation, who may, with the approval of the commission, appoint such assistants and employees as may be necessary to carry out the provisions of this Act. The director, assistants and employes shall receive such salaries, or compensation as may be determined by this Commission.

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Sec. 3. The said bureau shall have for its object and duties the following:

First: A study of the geological formations of the State with special reference to its mineral deposits, including oil, coal, gas, asphalt, gypsum, salt, cement, stone, clay, lead, zinc, iron, sand, road building material, water resources and all other mineral resources.

Second: The preparation and publication of bulletins and reports accompanied with the necessary illustrations and maps, including both general and detailed descriptions of the geological structure and mineral resources of the State.

Third: The consideration of such other scientific an economic questions as, in the judgment of the Commission shall be deemed of value to the people.

Sec. 4. The directors shall present to the Governor a biennial report, ready for printing, showing the progress and conditions of said bureau, together with such other information as the Commission may deem necessary: Provided, that the Commission shall have authority to print and to distribute said report.

Sec. 5. All materials collected, having served the purpose of the bureau shall be deposited in the State Museum: Provided, that duplicate may be distributed to the various educational institutions of the State under such regulations as the Commission shall formulate.

Sec. 6. In order to carry out the provisions of this act, it shall be lawful for all persons employed by the bureau to enter and cross all lands within the State. Provided, that in so doing, no damage is done to private property.

Sec. 7. Until suitable laboratories, libraries and testing apparatus are provided by the State for prosecuting the work of the survey, said survey shall be located at the State University. The Commisson shall enter into arrangements with the Board of Regents of the State University for the use, by members of the staff of the Survey, of such rooms, laboratories, libraries and apparatus as may be necessary for the carrying on of such work.

Sec. 8. The sum of fifteen thousand ($15,000) dollars or so much thereof as may be necessary, is hereby appropriated out of the funds in the State Treasury, not otherwise appropriated, to provide for the payment of actual expenses of the Commission, and for other expenses authorized by them, and for the salaries or other compensation of the director, assistants or other employes.

Sec. 9. For the preservation of the public peace, health, and safety, an emergency is hereby declared to exist by reason whereof this act shall take effect and be in force from and after its passage and approval.

GEORGE W. BELLAMY, President of the Senate.
WM. H. MURRAY, Speaker of the House of Representatives.
Approved, May 29, 1908.
C. N. HASKELL, Governor of the State of Oklahoma.

ORGANIZATION.

This bill was approved by the Governor, May 29th, 1908. On July 25th, the Governor called the Commission together and the organization of the Survey was accomplished.

In pursuance of the above bill, the Governor C. N. Haskell, the State Superintendent of Public Instruction, E. D. Cameron, and the President of the State University, A. Grant Evans, met in the Governor's office.

Upon motion of E. D. Cameron, seconded by A. Grant Evans, Governor C. N. Haskell was elected President of the State Geological Commission.

The State Superintendent E. D. Cameron, was elected Secretary of the Commission, and the President of the University, A. Grant Evans, was elected Executive Officer. Upon motion, the Secretary was directed to purchase a substantial record book and to make a record of all actions of the Commission therein.

On motion, Chas. N. Gould, a geologist of established reputation, and now acting as Professor of Geology at the State University, was elected Director of the Geological Survey.

The following resolutions were adopted:

That Executive Officer be empowered to certify to the State Auditor, the amount of money required to pay the salaries of the Director and other expenses as may be authorized by the Commission.

That the Executive Officer, by empowered, to arrange with the Board of Regents of State University for such rooms, laboratories, libraries, and testing apparatus as may be necessary for the work of the Survey, as provided in section seven of the Act establishing the Surevy.

That President of the Commission make know to the Director of the United States Geological Survey, in Washington, and to heads

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of the Geological Surveys in the neighboring state the organization of the Oklahoma Geological Survey, and to ask their official aid and co-operation.

That the Director of the Survey be authorized in the name of the Commission, to solicit the friendly aid and co-operation of all the citizens of Oklahoma, and particularly all teachers, and other professional men of the State.

That in conformity with Article three of Section three of the Act establishing the Commission, the Executive Officer is authorized on the advice of the director to appropriate such funds of the Survey as he may think wise to the investigation of zoological and botanical problems of the State.

That the Executive Officer is authorized to apportion the funds of the Survey, to approve the appointment of assistants and other employees and to see that the instructions of the Commission are faithfully carried out.

INSTRUCTIONS.

The folowing general instructions to the Director of the Geological Survey were adopted:

To proceed to ascertain the relations existing between the different rock formations at or near the surface of the earth in Oklahoma and to prepare reports properly illustrated, setting forth these facts.

To examine as rapidly as possible, the various mineral resources of the State and prepare reports outlining their distribution.

To collect, name, and arrange a collection of specimens illustrating the geology and mineral resources of the State.

To assist the colleges and high schools in making collections of geological and mineralogical specimens.

To disseminate, as widely as possible, particularly by correspondence and public addresses, correct ideas as to the occurrence, origin, and relation of rocks, minerals and ores.

To answer all reasonable inquiries relative to the mineral resources of the State.

To examine, upon petition of fifty freeholders, properly certified by the county clerk, lands upon which valuable mineral resources may be thought to exist.

To analyze free of cost, such specimens as in the opinion of the director, may be thought, to contain valuable minerals or which would further the work of the survey.

To prepare a schedule of prices to be charged by the chemist of the Survey for analysis made of such material, as is not analyzed on the authority of the director.

To co-operate with the United States Geological Survey, other bureaus of the United States Government and other State Surveys, whenever benefit will accrue to the State.

The Director of the Geological Survey was also given special instructions as follows:

Begin immediately to investigate the location and accessibility of various building stones of the State, including limestone, marble, sandstone, granite, gabbro, gypsum, dolomite, and porphyry, with pressure tests to determine the availability of all this stone for the construction of public buildings.

Begin immediately to investigate the location and availability of all stone, clay and other minerals of the state, suitable for the construction of roads, with ample tests to determine the relative value of the different materials in the construction of roads.

Begin immediately to investigate as fully as possible the oil and gas field of Oklahoma. Also to prepare and present to the Commission, reports fully illustrated setting forth the facts relating to these subject.

On September 1st, 1908, Mr. L. L. Hutchison was appointed Assistant Director of the Survey.

FIELD WORK IN 1908.

In pursuance with the instructions of the Commission, the director organized a number of parties for field work, as follows:

Mr. L. L. Hutchison, Assistant Director of the Survey, was in charge of a party consisting of Ben C. Belt, Artie G. Reeds, W. J. Cross, and T. R. Corr, which organized at Tulsa, and spent the season in Tulsa, Creek, Okmulgee, Muskogee and Wagoner Counties, investigating the oil and gas fields in that region.

A party was organized at Ponca City, and placed in temporary charge of Mr. H. A. Everest. Messrs. E. Z. Carpenter and H. G. Powell were assistants. Later in the season, Dr D.

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W. Ohern, Professor of Mineralogy at the State University, assumed charge of this party. The party traveled east across Osage, Washington, Nowata and Craig counties, then south and west across Rogers, Tulsa, and Osage counties, to Ponca City. The work consisted in maping the limestone, sandstone, and clay beds and studying oil and gas conditions and the occurence of coal.

Mr. Pierce Larkin was assigned to work in the Cretaceous rocks in southern Oklahoma. Starting from Atoka, he worked south and east across Atoka, Bryan, Pushmataha, Choctaw and McCurtain counties, as far as the state of Arkansas. He mapped a number of formations and made extensive studies of building stone, road material, and Portland cement rock.

Mr. C. A. Reeds, spent the season investigating the mineral resources of the Arbuckle Mountains. Mr. Reeds had already spent three seasons in this region and was more familiar with the country than any other man in the state. He is now at work preparing a report on the subject for publication.

Dr. J. W. Beede, Professor of Geology at the Indiana University spent four weeks in the northern part of the state, studying the limestone and shale of Kay, Osage, and Noble couties, with reference to their geological structure and the occurence of building stone and Portland cement rock. Dr. Beede was assisted several days by Dr. D. W. Ohern, and for the last two weeks by Mr. Artie C. Reeds.

Messrs Frank A. Herald and Chester C. Clark, were assigned to work in the gypsum region in Western Oklahoma. During the summer they visited Blaine, Beckham, Greer, Jackson, Caddo and Grady counties searching for deposits of gypsite and mapping the occurence of gypsum and salt.

Mr. G. W. Kneisly, undertook the study of the granitic rock of the state. He spent three weeks in Greer, Jackson, Kiowa and Comanche counties, and made good collections of granite and gabbro from the Wichita mountains. He then visited Murray and Johnston counties and made extensive collections from the Tishomingo region.

Mr. Gaylord Nelson, was assigned work in the eastern part of the state on Portland cement beds. He visited several localities and collected material from Ottawa, Craig, Mayes, Adair, Cherokee, Sequoyah, Muskogee, Wagoner, Rogers, Washington and Pontotoc counties. He visited and took extensive notes on the two Portland cement mills in the state, one at Ada and one at Dewey. He also spent several days in the Miami lead and zinc region, in the tripoli region in the eastern part of Ottawa county, near Seneca, Missouri, and at the marble quarries near Marble City, in Sequoyah county.

Mr. Key Wolf was assigned to the work of tracing out a ledge of limestone in southeastern Oklahoma, known as the Wapanucka limestone. He followed this ledge from Coal county, north and east across Atoka, Pittsburg, and Latimer counties. During the latter part of the season, he assisted Mr. C. A. Reeds, in the Arbuckle Mountains.

During the fall and winter of 1908, Messrs. H. A. Everest, E. L. DeGoyler, and John Bennett, were employed in the eastern part of the state, mapping the outcrops of coal and limestone in that region

REPORTS

Maps are now being prepared and reports written covering the topics mentioned in the instruction to the Director, viz:

1. A preliminary report on the building stone of Oklahoma, by Chas. N. Gould.
2. A preliminary report on the oil and gas resources of Oklahoma, by L. L. Hutchinson.
3 A preliminary report on the road material of Oklahoma. by Chas. N. Gould.

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4. A preliminary report on the Economic Products of the Arbuckle Mountains by Chas. N. Gould and Chester A. Reeds.

It is expected that these reports will be submitted to the Commission for printing at the time of the convening of the next legislature.

PURPOSE.

As stated in the Law and in the Instructions to the Director, the chief purpose of the Survey is to investigate and develope the mineral resources of the State. Few states in the Union have either as many kinds of materials or as much mineral of a kind as has Oklahoma. Our state has vast deposits of coal, oil, gas, asphalt, salt, gypsum, lead, zinc, limestone, granite, marble, sandstone, glass sand, cement rock and clay, and smaller quantities of a number of minerals such as copper, tripoli, volcanic ash, novaculite, and possibly the rarer metals, gold and silver.

At the present time very little of this mineral wealth is being developed. Oklahoma mines a little coal. A small part of the oil field has been developed. There are two Portland cement mills anld eight gypsum plaster mills at work. Lead and zinc is being mined on a small scale. A little asphalt has been taken out. Half a dozen pressed brick plants are at work,

Few of these industries, however, are more than started; and in many cases not even a beginning has been made. With vast undeveloped resources, the people of Oklahoma are importing nearly everything they use in the way of manufactured articles. Such things as salt, lime, cement, brick, tile and other clay products, coal, granite, limestone, marble, and asphalt are shipped into Oklahoma, and the consumer pays an excessive freight in addition to the cost of the material.

To develop these dormant resources, is the object of the Survey. To this end, parties are sent into the field to investigate specific problems, reports are written and distributed, and every possible effort is made to call attention to the mineral wealth of the state.

The survey is paid for by the people of Oklahoma and is administered for their benefit. It can undertake the examination of private projects and enterprises only in so far as such examination will advance the public welfare, and aid in the development of the State's dormant resources.

Two mistaken ideas are prevalent, namely; first, that the Survey will examine free of charge any so-called mineral prospect in the state; and second, that the Survey maintains a free assay bureau. Both these notions ar erroneous. So many requests of this character are constantly coming in that if all were granted, the staff of the Survey would do nothing else but investigate so-called mines and assay worthless material.

In order to do justice to all and at the same time to render the service of the survey most effective, the regulations on the following pages have been formulated:

EXAMINATION OF PROPERTY.

The Survey has no desire to engage in the work which properly belongs to the practical geologist and mining engineer, and for that reason cannot ordinarily undertake the examination of private enterprises. All prospectors, miners, and private companies, engaged in promoting individual enterprises should secure the services of a competent, practicing, scientific expert.

On the other hand the Survey is ready to examine regions supposed to contain deposits of value, provided that a sufficient number of people are interested in the matter to justify the expenditure of State appropriation. To cover cases of this kind, a special form of petition has been prepared which will be sent on application to the Director.

The petition is worded as follows:

(b). Each sample must be enclosed in a canvas bag or strong wrapper carefully labeled.

(c). The parcel must be forwarded prepaid to

The Director of the Oklahoma Geological Survey,
Norman, Oklahoma.

(d). A letter must be sent at the same time to the same address giving necessary information regarding the specimen.

(e). The exact locality where the sample was found (which must be in the State of Oklahoma) must be accurately disclosed.

4. The Director of the Survey reserves the right of publishing at any time the results of any assay made at public expense.

CO-OPERATION.

The Director of the Survey is very anxious to co-operate
in every way possible with any one who is endeavoring t [illegible]
velope the mineral wealth of the State. To this end h [illegible]
correspondence from stone men, brick manufacture [illegible]
oil operators, cement and plaster men, lead. [illegible] e work which
miners, and all other parties engaged in [illegible] and mining engi-
sources of Oklahoma. He desires to as [illegible] y undertake the ex-
adequate water supply, to aid in the co [illegible] ospectors, miners, and
to advise with farmer's unions, com [illegible] oting individual enter-
prise [illegible] ations, and in eve [illegible] se [illegible] of a competent, practicing,
scientific [illegible] of Oklah [illegible]

On the [illegible] hand the Survey is ready to examine regions supposed to contain deposits of value, provided that a sufficient number of people are interested in the matter to justify the expenditure of State appropriation. To cover cases of this kind, a special form of petition has been prepared which will be sent on application to the Director.

The petition is worded as follows:

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Harry R. Johnson

Branner Geological Library, Stanford University

OKLAHOMA GEOLOGICAL SURVEY

Governor Lee Cruce, State Superintendent R. H. Wilson,
President A. Grant Evans, Commission.

Chas. N. Gould, Director.

CIRCULAR No. 2

BRIEF STATEMENT
OF THE
GEOLOGICAL HISTORY
OF
OKLAHOMA

By CHAS. N. GOULD, Ph. D.

HARRY R. JOHNSON,
1101 L. A. Stock Exchange Bldg.
Los Angeles, California
Phone 150-58

NORMAN
July, 1911

HARRY [illegible]
1101 L. A. Stock Exchange Bldg.
Los Angeles, California
Phone 159-[illegible]

BRIEF STATEMENT

OF THE

GEOLOGICAL HISTORY OF OKLAHOMA

By Chas. N. Gould

Classes of Rocks

Geologists divide the rocks on the earth's crust into three general classes, igneous, sedimentary, and metamorphic.

Igneous or crystalline rocks are those which were part of the original earth's crust, or which have come up from the interior of the earth. Some of the chief types of igneous rocks are granite, basalt, porphyry, gabbro, diorite and rhyolite.

Sedimentary or stratified rocks are those which were originally laid down as sediments, usually in some large body of water. The material which makes up the sedimentary rocks was derived originally either from igneous rocks or from some other sedimentary rocks. These rocks have been deposited usually in regular layers or strata, hence the term stratified. The chief classes of sedimentary rocks are shales, sandstones and limestones.

Metamorphic rocks are those that have been metamorphosed or changed from their original condition by the action of heat and pressure. Limestone, when changed, becomes marble, shale becomes slate, and sandstone becomes quartzite.

Rocks of all the kinds mentioned above occur in Oklahoma. Igneous rocks, chiefly granite and porphyry, are found in the Wichita and Arbuckle mountains and in a small area along Spavinaw Creek in eastern Mayes County. On the map the areas occupied by igneous rocks are shown in solid black.

Sedimentary rocks, consisting of shale, sandstone and limestone occupy more than ninety percent of the area of Oklahoma Metamorphic rocks, usually marble and slate, occur in the mountain regions.

During geologic time that part of North America now included in the State of Oklahoma has been alternately submerged below the ocean and elevated above it many times. During the periods of submergence beneath the water, various kinds of deposits were laid down on the ocean bottom. When the country was raised above the water these deposits hardened and became solid rock. When the land stood out of the water for any length of time, the action of the elements rain, wind, water and frost, wore away the rocks and carried them through rivers into the ocean.

Geologic Time Scale

Geological time is divided by geologists into the following eras: Archean, Algonkian, Paleozoic, Mesozoic and Cenozoic. These eras are again subdivided into periods and the periods into minor subdivisions. The rocks deposited during a period of time are called a system. The rocks deposited during the Cambrian period make up the Cambrian system. In the following table, the systems and such minor subdivisions as are well represented in Oklahoma are shown. The oldest rocks are placed below:

Cenozoic	Quartenary	Pleistocene
	Tertiary	Pliocene Miocene
Mesozoic	Cretaceous	Upper (Dakota) Lower (Comanche)
	Jurassic	
	Triassic?	
Paleozoic	Carboniferous	Permian Pennsylvanian Mississippian
	Devonian	
	Silurian	
	Ordovician	
	Cambrian	
Archean		

Rocks Exposed in the Arbuckle and Wichita Mountains

The oldest rocks in Oklahoma are the granites, presumably of Archean age, and are exposed in the Wichita and Arbuckle mountains. Granite is usually considered a part of the original crust of the earth, and granite or some form of igneous rock, underlies all the stratified rocks; that is to say, if a hole were drilled deep enough anywhere on the surface of the earth it would encounter the igneous rock. We may assume that all of Oklahoma is underlain with some form of igneous rock, probably granite, which, however, is now exposed in but a few places. About the middle of Cambrian times the sea surrounded the granite peaks and a deposit of sand derived from the granite was laid down along the shore line. This sand now appears as a ledge of coarse-bedded sandstone, known as the Reagan sandstone. Lying upon the granite, in the Wichita and Arbuckle Mountains, the sandstone is composed largely of coarse feldspar and quartz-fragments and is generally too coarse to make a good building stone.

The sea in which the Reagan was deposited, deepened, or the land surface was lowered so that the granite was entirely submerged. In this sea a great mass of limestone and dolomite was deposited, which so far as known is one of the thickest limestone formations in the world. This is known as the Arbuckle limestone. Its exact thickness is unknown, but is estimated by Mr. Taff, formerly of the United States Geological Survey, who has studied the formation, to be somewhere between 6,000 and 8,000 feet. Limestone of the same age as the Arbuckle, very similar to it in character and almost equal to it in thickness occurs in the Appalachian Mountains and in other parts of the country. These deposits are believed to be continuous although they are so deeply buried under younger formations as to make it impossible to trace any connections. If this is true, Oklahoma at the time of the deposition of the Arbuckle limestone, must have been a portion of a great sea which covered most of the United States. These conditions must have endured for an immense length of time, probably for hundreds of thousands or even millions of years, to permit the accumulation of such a great thickness of limestone and dolomite which, necessarily, is deposited very slowly.

Early in Ordovician time, after the deposition of the Arbuckle limestone conditions changed from that of a deep sea to a shallow sea, and a deposit consisting of shale, sandstone, and thin-bedded limestone was laid down. This formation, which is about 2,000 feet thick is known as the Simpson formation.

About the middle of Ordovician time conditions again changed this time from a shallow to a deep sea and another heavy ledge of limestone was deposited. This formation, known as the Viola limestone, is about 800 feet thick, and consists of heavy bedded white or blue limestone.

During the early part of the Silurian period the Sylvan shale was deposited. It is 100 to 200 feet thick and may be used for the manufacture of Portland cement or for various other clay products.

Above the Sylvan is a formation known as the Hunton limestone, which consists of three members, a limestone at the base, then a shale member, then another limestone at the top. The upper and middle portions of the Hunton are of Helderbergian or lower Devonian age . The entire thickness of this formation is usually less than 200 feet.

After the deposition of the Hunton limestone, the region was elevated above the ocean and erosion took place. In many places much of the upper part of the Hunton was carried away, and occasionally all of it has been removed. Then, in late Devonian time, the region again sank and there was laid down in still water a deposit of mud and silt, which, on hardening, became a hard, brittle shale, containing many concretions and bands of chert. The formation is known as the Woodford chert. Limestone, known as the Sycamore, was deposited locally on top of the Woodford chert.

Above the Sycamore are shales and sandstones of Carboniferous age, which will be described later.

The formations so far described are well exposed in the Arbuckle Mountains, in Murray, Johnston and Pontotoc counties. The Reagan, Arbuckle and Viola formations are exposed in the Wichita Mountains also, and the others are almost certainly present although deeply buried and not now exposed.

After these rocks had been deposited there occurred one of those periods of emergence, which have occured at intervals throughout geologic time. The regions occupied by the Arbuckle and Wichita Mountains were elevated in the form of two vast domes, each about 60 miles long and 20 miles wide. The amount of upheaval was probably about two miles above their present level. As soon as this uplift occurred and the rocks stood out of water, the agents of erosion, wind, rain, frost, and heat began to wear down the mountains. The upper rocks were first destroyed, and carried into the ocean. Afterward the rocks more deeply buried were attacked and carried away. In time all the sedimentary formations were worn away in places exposing the granite core of the mountains. This granite now stands out as high, jagged peaks in the Wichita Mountains, while in the Arbuckles it is exposed in the country around Tishomingo, and in the East and West Timbered Hills south and west of Davis. Surrounding the granite and flanked upon all sides of it are the various sedimentary formations mentioned above lying in regular order, beginning with the Reagan and ending with the Sycamore. In passing from the Washita River near Davis to the East Timbered Hills, a distance of four miles, one will walk over the uplifted cut-off edges of about two miles of sedimentary rocks.

Rocks Exposed in the Ozark Uplift

The regions heretofore described are in southern Oklahoma. In the northeastern part of the State, conditions were somewhat similar. In this region which is the southwestern extension of the Ozark Uplift, a number of formations, consisting of limestone, sandstone and shale, were laid down under varying conditions, either in the ocean or along the shore. The Yellville limestone and dolomite (not exposed in Oklahoma but near by in Arkansas) was deposited about the same time as the Arbuckle limestone.

The Burgen sandstone was laid down about the same time as the Simpson formation, the St. Clair marble about the same time as part of the Hunton limestone, while the Chatanooga shale corresponds in age to the Woodford chert.

The most important formation in this part of the State, however, is a ledge of limestone and chert, some 300 feet thick, known as the Boone chert, which was deposited in Mississippian time. It is of about the same age as the Sycamore limestone in the Arbuckle Mountains. This is the formation in which the lead and zinc of the Joplin and Miami districts occur. The limestone quarried at Carthage, Missouri, comes from this formation also. The Boone formation is exposed on the surface in Ottawa, Delaware, Adair, Cherokee and Mayes counties, where it forms the surface of the upland plateau lying between Grand River and the Arkansas-Missouri line.

Above the Boone is a shale formation, the Fayetteville shale, and above the Fayetteville a limestone known as the Pitkin limestone. This limestone is hard and durable and would make a splendid building stone. The Fayetteville and Pitkin are both thought to be of Mississippian age.

After the deposition of the formations just described which occupy much of southern Missouri as well as northeastern Oklahoma and northern Arkansas, there occurred an upheaval, very similar to the one which brought up the Arbuckle and Wichita Mountains. The rocks were elevated in the form of an immense dome. Erosion immediately began its work on the uplift and in many places the Pitkin, Fayetteville and much of the Boone formation have been removed, while in some of the deeper valleys along the White River in Arkansas the older formations down to the Yellville limestone are exposed.

Rocks Exposed in the Ouachita Mountains

The Ouachita (Wa-she-taw) Mountains are located in southeastern Oklahoma, extending from near Atoka east to the Arkansas line. They consist chiefly of long narrow ridges, composed of thick ledges of sandstone standing on edge, with intervening shale valleys. The various ridges have received names such as Winding Stair, Kiamichi, Jack Fork, Pine and Buffalo mountains. There are no igneous rocks exposed in the Ouachita Mountains, as is the case in the Arbuckles and Wichitas. The oldest rocks in this part of the State consist of certain exposures of chert and shale of Ordovician age which outcrop in three localities, namely, in the Potato Hills west of Talihina; in Atoka County between Stringtown and Atoka, and along Mountain Fork and Glover Creek in eastern McCurtain County.

Lying above these older rocks are immense deposits of sandstone and shale which were laid down during early Carboniferous times. The exact age of these rocks is not known, but they are probably early Pennsylvanian. Three separate formations have been described; the Standley shale, 6000 feet thick, which lies on the Ordovician rocks; the Jackfork sandstone, 5000 feet thick; and the Caney shale, 1500 feet thick. The Caney shale is also exposed in the country surrounding the Arbuckle Mountains. All these rocks have been tilted and now stand on edge. It is the heavy, persistent Jackfork sandstone that now makes up the long ridges of the Ouachita Mountains, while the Standley and Caney shales, being softer have worn away forming valleys.

Pennsylvanian Rocks

All the depositions and upheavals heretofore described occurred in early geologic time, before the close of the middle Carboniferous or Pennsylvanian time. In the Arbuckle Mountains, the Sycamore limestone is probably of Carboniferous age and in the northeastern part of the State the Boone, Fayetteville and Pitkin are Mississippian in age. In the Ouachita Mountains the Jackfork and Caney formations are Mississippian or Pennsylvanian.

About the time that these uplifts occurred, or possibly earlier, there was a great shallow basin or arm of the ocean occupying what is now east-central Oklahoma. This basin seems to have been connected with another arm which extended north through what is now central Oklahoma, Kansas and Nebraska. The basin must have extended far to the west, but we have no means of knowing just how far. The streams rising in the uplifted mountain regions just described, emptied their accumulated sediments into this basin so that in time there were laid down immense deposits of sand and mud. Great plants grew in the swamp-like basin and the vegetation accumulated in immense quantities. As time went on the mass of vegetation which was laid down in the basin became coal. The sand hardened into sandstone and the mud formed shale. These formations are more than ten thousand feet in thickness and belong to the Pennsylvanian or Coal Measures age. The rocks of this age now occupy about one-third of the State and consist largely of alternate ledges of shale, sandstone and coal, although in the northern part of the State, farther from the mountain uplifts, there are a number of ledges of limestone. The shales are much more abundant than the other rocks, and occupy perhaps three-fourths of the thickness of all the formations.

The Pennsylvanian area is separated from the Ouachita Mountain uplift by the Choctaw fault. North of this fault lies the Wapanucka limestone, the only limestone ledge in this part of the State. Above the Wapanucka the formations, in ascending order, are, Atoka formation, Hartshorne sandstone, McAlester shale, Savanna sandstone, Boggy shale, Thurman sandstone, Senora formation, Stuart shale, and Calvin sandstone. The combined thickness of these various formations is about 8500 feet. These rocks are exposed in that part of the State extending from the Choctaw fault north to the Arkansas River, and nearly as far west as the Sapulpa-Denison branch of the St. Louis & San Francisco Railroad.

Among the Pennsylvanian rocks of northern Oklahoma there are a number of ledges of limestone which lie interbedded among the sandstones and shales. Great numbers of shells and other forms of marine life, preserved as fossils, make up the greater part of the limestone ledges . These ledges enter Oklahoma from Kansas and pass southward, usually bearing off a little to the west, about as far as the Arkansas River, where they usually thin out and finally disappear. Only a very brief description of the various ledges need be given here.

The lowest limestone of Pennsylvanian age enters Oklahoma a few miles west of Grand River in central Craig County, and passes southwestward near the towns of Centralia, Chelsea, Claremore and Catoosa and crosses the Arkansas River south of Broken Arrow. This formation was formerly known as the Fort Scott limestone, but is now called the Claremore. Above this formation shales occur and above the shales is another ledge of sandstone known as the Pawnee, which parallels the Claremore a few miles to the west, passing southward toward the Arkansas River. Then come other shales and a ledge of limestone known as the Altamont, which unites with the Pawnee at Oolagah and the two are known as the Oolagah limestone. Above is another thick bed of shales, which is succeeded by another limestone—the Lenapah, which passes from Kansas southwest through Nowata, Lenapah and Tulsa as far as North Canadian River. Other limestone ledges lying west of the Lenapah are known as the Hogshooter, Dewey, Avant and Piqua. Eastern Osage County is occupied largely by ledges of shale and sandstone and no other important limestone is found while passing westward until a point four miles west of the town of Pawhuska is reached where there is a very heavy limestone formation known as the Pawhuska formation, composed of three members which cap the hills of that region.

Western Osage County is occupied by the southern part of the Flint Hills of Kansas. The rocks consist of alternating layers of limestone and shales and sandstone all of which dip westward. There are a number of ledges of limestone in western Osage and eastern Kay counties, the most important of which are the Wreford, Fort Riley, Winfield, and Herrington limestones. These formations cannot be traced farther south than Noble County.

Permian Rocks

Lying west of, and above the sandstone, shale and limestone of Pennsylvanian age, is a great series of red shales known as the Redbeds. This series of rocks, consist of unknown thicknesses of red clay shales, containing occasional ledges of some other material, usually gypsum, sandstone, or dolomite. These rocks occupy all the country from about the eastern line of old Oklahoma westward across the State, surrounding the Wichita Mountains, and extending across the Panhandle of Texas, as far as New Mexico. The Redbeds seem to have been deposited during a time of withdrawal of the sea and also of extremely arid climate. They contain very few fossils and their red color is apparent proof that little organic matter was buried with them. Very few ledges can be traced for any distance, so that the thickness of the Redbeds is not known. The extensive gypsum deposits in western Oklahoma belong to the Permian Redbeds.

While it is generally true that the Permian rocks in Oklahoma are red and the Pennsylvanian rocks non-red, there is a strip of country extending north and south through central Oklahoma where conditions are otherwise. In other words, it seems that the line of change in color in the rocks does not coincide with the line of separation between the Pennsylvanian and Permian. This condition is shown on the map where the areas of red Pennsylvanian and non-red Permian are shown. The actual line of contact between the Pennsylvanian and Permian as shown on the map has not been accurately located.

The Permian rocks of Oklahoma have been divided into five formations as follows: The Enid formation consists largely of red shale and includes all the lower part of the series as exposed in the country east of the main line of Gypsum Hills. The Blaine formation consists of heavy ledges of white massive gypsum, which make up the main line of the Gypsum Hills, and outcrops along a line extending from near El Reno north to Kansas. The Woodward formation lies west of the Gypsum Hills and consists of red shales and sandstones. The Greer formation is made up of several ledges of massive gypsum. It is exposed in a number of counties in western and southwestern Oklahoma and crosses Red River into Texas. The Quartermaster formation which lies above the Greer is made up largely of soft sandstone. It is exposed chiefly in Beckham, Washita, Custer and Roger Mills counties.

Triassic or Jurassic Rocks

After the rocks of the Pennsylvanian and Permian age had been deposited, all that part of America now occupied by Oklahoma was raised above the ocean and for a long period of time remained out of the water, in fact so far as we know, only the southeastern part and certain regions of western Oklahoma have again been submerged since Permian time.

With the possible exception of a few unimportant formations of doubtful age which outcrop along the Cimarron River in the extreme northwestern part of Cimarron County, there are no rocks of either Triassic or Jurassic age in the State, which indicates that all of Oklahoma was a land area through those periods.

Cretaceous Rocks

During the Cretaceous period, that part of Oklahoma which lies south of the Arbuckle and Ouachita Mountains, all of eastern Texas, and southern Arkansas were submerged and a number of different formations were deposited.

The oldest Cretaceous formation in Oklahoma is known as the Trinity sandstone, and is composed largely of coarse sand and clay. The Trinity, which is from 400 to 600 feet thick, was probably deposited along the margin of a sea which at one time marked the southern base of the Arbuckle Mountains. This formation, as exposed on the surface, extends from near Ardmore to the Arkansas line and dips south passing beneath the next younger formations. After the deposition of the Trinity the water deepened and a limestone formation was deposited. It is about twenty-five feet thick, usually white in color and is known as the Goodland limestone. After the deposition of this limestone there was a shallowing of the sea and a series of mud and calcareous shell rock was deposited to a depth of thirty to fifty feet.

The sea again deepened and the Caddo limestone was deposited. This formation is about 150 feet thick and consists of clay, calcareous marls and white or yellow limestones. There was another shallowing of the sea and a series of clays and sand, with thin beds of limestone were laid down. This formation is known as the Bokchito and is about 150 feet thick. The sea again deepened and the Bennington limestone 80 to 100 feet thick was laid down. Above the upper limestone members there was laid down a deposit of sand and clay. This sandstone is known as the Silo sandstone.

At the time that southeastern Oklahoma was covered by a Cretaceous sea, there seems to have been an embayment of another sea extending from Kansas and Colorado south across the western part of the State. In a number of the western counties there are deposits of shell rock containing fossils of Cretaceous age lying on the unevenly-eroded surface of the Redbeds. These were probably laid down at about the same time as the Goodland or Caddo limestone of southern Oklahoma. There is no means of determining just how far this sea extended but deposits have been found in Woods, Harper, Woodward, Dewey, Custer, Roger Mills and Washita counties.

In the extreme northwestern part of Oklahoma along the valley of the Cimarron River there are rocks of Cretaceous age also. These consist largely of sandstone and shales, the upper members being the Dakota sandstone of the same age as the Silo. This formation is found very abundantly in Kansas, Nebraska, and other states in the northern part of the Great Plains.

Tertiary Rocks

During late Cretaceous times Oklahoma stood out of the water and so far as we are able to learn it has remained a part of the unsubmerged continent ever since. During Tertiary times, however, the Rocky Mountains, which were then much higher than at the present time, were being eroded and washed away, and the material derived from them, consisting of sand, clay and gravel, was carried by streams and spread out on the western part of what is now the Great Plains. Much of western Dakota, Nebraska, Kansas and Oklahoma, northern Texas and eastern New Mexico, Colorado, Wyoming and Montana contain deposits of Tertiary age derived from the waste of the Rocky Mountains. In Oklahoma Tertiary deposits occur in the three western counties, Cimarron, Texas, and Beaver, and in a number of other counties in the western part of the State. These formations are exposed as white cliffs or banks along the streams. The sheet water of the Plains is found usually near the base of the Tertiary, and the many perennial springs in this region obtain their supply from the same rocks.

There are many places in western Oklahoma where sand hills occur, but they are usually found most abundantly north of such streams as Salt Fork, Cimarron, North Canadian and South Canadian. It is believed that much of the sand which goes to form these hills was derived principally from Tertiary deposits, and that the hills have been shaped by the winds. A considerable amount of the sand was undoubtedly carried from the various streams by strong south winds.

In the extreme northwest corner of the State there is a deposit 150 feet thick and some 10 miles in area of black volcanic lava. The rock came originally from a volcano, which in Tertiary times was located just west of what is now the Oklahoma line, in southeastern Colorado.

Quarternary Rocks

The Quarternary or Pleistocene deposits of Oklahoma consist largely of the alluvial soil or bottom land along the streams, and fine silt and soil forming the so-called black upland on many of the divides. The deposits do not form rock, as the term is popularly understood.

Minerals in the Rocks

Many of the formations described above contain various minerals some of them in immense quantities; many of them extremely valuable.

Some of the finest granite in the world is found in the Arbuckle and Wichita mountains. These granite rocks also contain small quantities of gold and silver, but so far as known these minerals have not been found in paying quantities in Oklahoma.

Limestone is found widely distributed in the State, chiefly in the mountain regions, and in the Pennsylvanian area in the northern counties. The greater part of this limestone is suitable for building stone, for burning into lime, for the manufacture of Portland cement, for concrete rock, road material, and for many other uses.

Sandstone is widely distributed, being found in rocks of practically all ages. The best sandstone is found in Pennsylvanian and Cretaceous rocks. The Simpson sandstone in the Arbuckle Mountains and the Burgen sandstone near Tahlequah, contain vast deposits of glass sand. Clays and shales suitable for a very large variety of clay products occur in all formations and widely distributed.

Coal occurs chiefly in the Pennsylvanian rocks of eastern Oklahoma where at least ten workable beds are found. The government estimates that Oklahoma contains 79,000,000,000 tons of coal.

The greater part of the petroleum and natural gas so far found in the State comes from the Pennsylvanian rocks also. The amount of these fuels is so great that it cannot now be estimated.

Asphalt occurs widely distributed in southern Oklahoma, chiefly in the Arbuckle and Wichita mountains and in the Pennsylvanian rocks surrounding those mountains.

Lead and zinc occur chiefly in the Boone chert of Mississippian age in the northeast corner of the State, and in the Arbuckle limestone in the Arbuckle Mountains.

Iron ore occurs most abundantly in the Arbuckle, Viola and Hunton formations of the Arbuckle Mountains. Deposits are reported from the Wichita Mountains and from the Pennsylvanian rocks near McAlester.

Gypsum, of which it is estimated that Oklahoma contains 125,000,000,000 tons, occurs as members of the Permian Redbeds in the western part of the State. Salt occurs in large quantities in the same general region.

Among the minerals of minor importance, tripoli occurs in the Boone chert in the northeastern counties; novaculite or razor hone rock is found in the Ouachita Mountains, and beds of volcanic ash are stratified among the Tertiary deposits of the Plains.

LIST OF PUBLICATIONS

The following publications of the Oklahoma Geological Survey are either now available or will be off the press within the next few months:

Bulletins

Bulletin No. 1. Preliminary Report of the Mineral Resources of Oklahoma. Postage 3 cents.

Bulletin No. 2. Rock Asphalt, Asphaltite, Petroleum and Natural Gas in Oklahoma. Postage 10 cents.

Bulletin No. 3. Geology and Mineral Resources of the Arbuckle Mountains. Postage 6 cents.

Bulletin No. 4. Coal of Oklahoma (To be issued in December). Postage 6 cents.

Bulletin No. 5. Structural Materials of Oklahoma. Postage 6 cents.

Bulletin No. 6. Director's Report and Brief Chapters on twenty Oklahoma Minerals. Postage 3 cents.

Bulletin No. 7. Clays and Clay Industries of Oklahoma. Postage 10 cents.

Bulletin No. 8. Road Materials and Road Conditions in Oklahoma. (To be issued in September). Postage 7 cents.

Bulletin No. 9. Lead and Zinc in Oklahoma. (To be issued in November). Postage 8 cents.

Bulletin No. 10. Oklahoma Mineral Waters. (To be issued in November). Postage 8 cents.

Circulars

Circular No. 1. Origin, Scope and Purpose of the Oklahoma Geological Survey. (Edition Exhausted).

Circular No. 2. Brief Statement of the Geological History of Oklahoma. Postage 1 cent.

Circular No. 3. Oklahoma Among the Southern States. Postage 1 cent.

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OKLAHOMA GEOLOGICAL SURVEY
Governor Lee Cruce, State Superintendent R. H. Wilson,
President A. Grant Evans, Commission;
Chas. N. Gould, Director.

1945

CIRCULAR NO. 3

OKLAHOMA
AMONG THE
SOUTHERN STATES

An address delivered before the Southern Commercial Congress at Atlanta, Georgia.
March 6, 1911

—BY—

CHAS. N. GOULD, Ph. D.

Norman
August, 1911

PEERLESS PRESS OKLAHOMA CITY

Oklahoma Among the Southern States

BY CHAS. N. GOULD

You don't have to lie about Oklahoma; if you tell half the truth people won't believe you.

No equal area that the sun shines upon, during recorded history, has made such rapid material progress as has the state of Oklahoma, during the last decade. Her history reads like a romance. Those of us who have been actively engaged in aiding this development as well as those from other states who have watched the progress of Oklahoma, often stand aghast before the wonderful latent possibilities of the state.

RELATIVE RANK

It is not easy to attempt to condense into a single paragraph a statement of the wonderful resources of Oklahoma and their development. Some idea of conditions may be gained by reference to the government census reports recently issued, where it is shown that during the past ten years, among the sixteen states represented at the Southern Commercial Congress, Oklahoma ranks as follows:

First in percentage of increase of population of the state, 110%.

First in percentage of increase of population of two chief cities, Oklahoma City having 549%, and Muskogee, 494%.

First in percentage of increase of value of farm crops, 242%.

First in percentage of increase of wheat raised, 56%.

First in percentage of increase of cotton raised, 176%.

First in percentage of increase of railroad mileage, 154%

First in percentage of increase in lumber cut, 901%.

First in percentage of increase in corn raised, 921%.
First in percentage of increase in bank deposits, 1033%.
First among the southern states in the amount of petroleum produced during the past four years.
First in the amount of natural gas in sight.
First in the total amount of available fuel.
First in the total amount of asphalt.
First in the total amount of glass sand.
First in the total amount of gypsum.
First in the amount of salt.
First in the total amount of mineral products.
First in the total amount of wheat raised.
And first in the number of acres of fertile soil lying idle.

If you exclude Texas, our burly neighbor on the South, with an area nearly four times our own, and old Missouri, with an area nearly as large, and with nearly 100 years of development, Oklahoma ranks,
First in corn.
First in oats.
First in cattle.

Excluding Texas, Missouri and Georgia, the Empire state of the South, Oklahoma is,
First in hogs.
First in miles of railroad.

And excluding Texas, Missouri, and West Virginia she is,
First in assessed valuation.

HISTORY

Twenty-one years ago the greater part of Oklahoma was bare prairie or unbroken forest. In the eastern part of the State, which was owned and occupied by Indians of the Five Civilized Tribes, there were few small villages, little more than trading posts, built up largely of wooden shacks. Western Oklahoma was then totally unsettled. In April, 1889, the first land in the Territory of Oklahoma was thrown open to settlement. Cities sprang up as if by magic. An area half as large as that of the State of Maryland was settled in a day. From time to time, various Indian reservations were thrown open to the public and cities sprang up over night. During the past ten years the land of the Five Civilized Tribes in eastern Oklahoma has been allotted and much of it made available for purchase. Farms have been improved, mines and quarries have been opened, factories erected, railroads built and cities have grown, until, today, Oklahoma stands at the forefront of the sisterhood of states.

TOPOGRAPHY

Oklahoma is larger than any state east of the Mississippi River; the total area being 70,740 square miles. Generally speaking, the state is a level plain, sloping from and elevation of about 5,000 feet above sea level in the northwest corner to less than 400 feet in the southeast corner. Western Oklahoma is a flat or rolling prairie. In southern and eastern Oklahoma, this plain is interrupted by a number of ranges of high hills, dignified by the term mountains. These are known as the Wichita, Arbuckle, Ouachita, and Ozark mountains. The eastern half of the state contains forests of pine, oak and hickory. Western Oklahoma contains little timber except along the streams.

RAINFALL AND SOIL

Three-fourths of the State has an abundant rainfall, varying from 40 inches in the southeastern corner to 25 inches near the western line. The extreme northwestern part of the State, old "No Man's Land," lies in the semi-arid region of the Plains, the rainfall varying from 10 to 25 inches per annum.

Oklahoma is well watered by streams. Ten large rivers cross the State. All the drainage is into the Mississippi through the Arkansas or Red Rivers. The chief tributaries to the Arkansas are the Grand, Verdigris, Poteau, South Canadian, North Canadian, Cimarron and

Salt Fork. The chief tributaries of the Red are the Kiamichi, Blue, Boggy and Washita. The general course of these streams is from northwest to southeast across the State. In each stream valley there is a broad belt of exceedingly fertile bottom land, averaging from one to three miles in width. The upland soil throughout the greater part of the State is very fertile. In western Oklahoma much of the soil is red, which color is due to the large percentage of iron which it contains. Eastern Oklahoma contains several large areas of limestone soil.

AGRICULTURAL RESOURCES

The happy combination of abundant rainfall, warm climate and fertile soil, all conspire to render Oklahoma one of the most productive of the agricultural states. Practically everything that is cultivated between the Canadian line and the Gulf of Mexico, and between the Atlantic and the Rocky Mountains can be raised in Oklahoma. The four staples are corn, wheat, cotton and oats. In 1910, Oklahoma led the southern states in the production of wheat, more than 25,000,000 bushels being harvested. She ranks second in the production of oats, with 23,000,000 bushels; fourth in the production of corn with 92,000,000 bushels; and fifth in the production of cotton with 962,000 bales. In addition to these crops, Oklahoma ranks first in the production of broomcorn and among the first in the production of alfalfa. Many of her farmers have become wealthy shipping potatoes to northern markets, two crops a year being produced. Truck and vegetables are grown in all localities. The wild hay crop every year adds hundreds of thousands of dollars to the total wealth of the State.

Practically all kinds of fruits grow well. The apples of eastern Oklahoma rival those raised in the famous Ozark country of northern Arkansas and southern Missouri, this section of the state being a part of "the land of the big red apples." Elberta peaches, the finest raised in the Mississippi valley, grow big as pint cups, and are often a drug on the market at fifty cents a bushel. Cherries, plums, pears, grapes and fruits of all kinds grow in the greatest profusion. Pecans, walnuts and other nuts are abundant.

It must not be imagined for an instant, however, that Oklahoma has yet come into her own in the matter of agricultural development. The State Board of Agriculture is authority for the statement that at the present time, taking into consideration all known data, only about 24 per cent of the tillable land in the State is yet in cultivation. That is to say, three-fourths of our acreage, which includes much of the finest agricultural land in the United States, is still lying idle.

LIVE STOCK

In former years, Oklahoma was the stockman's paradise. Before the opening of the country to settlement, great herds of long-horned, Texas cattle roamed at will over the broad prairies. The nutritious grasses, indigenous to our soil, and the abundant water supply, made Oklahoma the best cattle country in the world. These conditions have passed. Instead of the half-wild long-horned cattle, we have well-kept herds of Herefords and Jerseys; instead of the tough and wirey cow pony, the draft horse and the racer; and instead of the wild hog, the Poland China and Berkshire. In 1910, Oklahoma ranked third among the southern states in the number of cattle and fourth in the number of hogs produced.

MINERAL WEALTH

No state in the Union possesses a greater variety or larger amount of undeveloped mineral wealth than does Oklahoma. During the past three years she has led the United States in the production of petroleum, and last year produced 54,000,000 barrels of crude oil. The amount of natural gas in sight, including that being utilized, that going to waste and that shut in, will approximate 2,000,000,000 cubic feet per day. At a conservative estimate, not to exceed 20 percent of the productive oil and gas fields have been developed. The United States Geological Survey is authority for the statement that the amount of coal in Oklahoma is 79,000,000,000 tons. These facts being true, it is obvious that so far as we have available data, Oklahoma possesses a greater amount of fuel than any other state in the Union. When it is remembered that approximately 90 per cent of all the power used in manufacturing and other industrial purposes is derived from one of these three fuels, it will be easily understood what the future development of Oklahoma may be.

But not in fuels alone is Oklahoma rich. The asphalt deposits in the southern part of the State are the most extensive in the Union. Complete data are not available, but at a conservative estimate, there is enough asphalt in this region to pave all the streets of all the cities in the United States for the next hundred years, and even then one would scarcely know from where the material was taken.

The lead and zinc deposits in northeastern Oklahoma are among the most prolific in this country. Within the last two years a million dollars have been spent in mines and mills on a single square mile near Miami, and more than that amount has been taken from the ground at this place in the form of lead and zinc ore. The area in which we may expect to find lead and zinc in paying quantities includes several thousand square miles.

Oklahoma possesses more gypsum than any other state. It is estimated that there are 123,000,000,000 tons of this material in sight in the western counties, which is enough to keep 100 mills, each manufacturing 100 tons a day, busy for 34,000 years. Oklahoma has enough salt water going to waste to make 100 carloads of salt a day. Her glass sand deposits are among the most extensive of those of any state. There is in southern Oklahoma a ledge of glass sand averaging fifty feet thick, and sixty miles long, which, on analysis, is found to be often 99.98 per cent pure silica.

The granite deposits of Oklahoma are among the finest in the country. Twenty or more varieties of shade and texture are found. The Wichita Mountains, 1000 feet high and sixty miles long, in southwestern Oklahoma, are composed entirely of granite. An area of more than 100 square miles in the Arbuckle Mountains is covered by granite.

Oolitic limestone, superior to the famous Bedford stone, occurs in very large quantities. Six separate areas in Oklahoma contain inexhaustible deposits of limestone, the greater part of which is suitable for the manufacture of Portland cement, for burning into lime, for concrete rock, and for building stone. Sandstone suitable for building is widely distributed. Clays and shales, suitable for the manufacture of brick, tile, sewer pipe and a large variety of clay products, are found in all parts of the State.

Oklahoma contains considerable deposits of high grade manganese iron ore; some of the finest tripoli in the country; great beds of volcanic ash; extensive deposits of novaculite; and a large variety of other minerals of minor importance.

WATER POWER

The water power resources of Oklahoma are extensive, but at the present time practically undeveloped. A number of swift-flowing streams, carrying constant volumes of water, cross the State. Power plants are now in operation at only four places, namely at Anadarko, Chickasha, and Pauls Valley, on the Washita, and at Tishomingo on the Pennington. Such rivers as Poteau, Kiamitia, Blue, Boggy, Grand, Verdigris, Illinois, North Canadian and Little River, and creeks such as Rock, Honey, and Mill, contain an ample supply of water to run scores, not to say hundreds of power plants, capable of generating many thousands of horse power.

Two rather ambitious projects are now being considered. One, located in south-central Oklahoma, contemplates the construction of 10 or 12 plants, at various points, along the Washita River, between Lindsay and Berywn. The combined power from these plants is to be carried to Oklahoma City, Shawnee, Ardmore and other towns in the central part of the State. A second project of nearly as great magnitude in the eastern part of the State contemplates the erection of a dam across Grand River near Muskogee. It is estimated that the power generated at this point, would be sufficient to supply light and power to a city of 200,000 people.

Other projects have been surveyed at Keokuk Falls and Weleetka on the North Canadian, at Carnegie, Fort Cobb, Cloud Chief, Lindsay, Pauls Valley and Dougherty, on the Washita; near Belton and Milburn on the Blue; at Tahlequah and Cookson on the Illinois. Suffice it to say that if the immense deposits of coal, oil and gas now lying dormant in our hills are ever exhausted, there is enough water power yet unutilized to supply all the plants, factories and mines that Oklahoma will ever need.

TRANSPORTATION

Oklahoma has 6,106 miles of railroad. Only Texas, Missouri, and Georgia among the southern states, exceed her in mileage. Most counties have two or more competing lines of railroad.

Five trunk lines across the State, namely, the Atchison Topeka and Santa Fe; the Missouri, Kansas and Texas; the St. Louis and San Francisco; the Kansas City, Mexico and Orient and the Chicago, Rock Island and Pacific. The Santa Fe has direct connection with Chicago, Kansas City, Denver, Galveston and California. The Missouri, Kansas and Texas connects with St. Louis, Kansas City and Galveston. Four lines of the St. Louis and San Francisco cross Oklahoma, giving direct connection with the Kansas City, St. Louis, Chicago and Texas points. The Rock Island crosses Oklahoma from both the north and east, connecting Chicago, Kansas City, Memphis and El-Paso. The Kansas City, Mexico and Orient reaches Kansas City on the north, and is building toward the Pacific Coast.

Besides these trunk lines, there are a number of lines of minor importance, including the Missouri Pacific; Missouri, Oklahoma and Gulf; Fort Smith and Western; Midland Valley; Oklahoma Central, and several shorter lines.

THE NEED OF FACTORIES

Oklahoma's greatest need today is more factories. With unlimited natural resources, both agricultural and mineral, with a larger amount of fuel than any other state, and inexhaustible water power, Oklahoma is, at the present time, manufacturing very few of the comforts and necessities of life used by her people. Nine-tenths of the manufactured articles used in Oklahoma are imported from other states. Our people are today paying the market price plus the freight for the greater part of the articles which they use. At the same time the farmers of Oklahoma are able to sell their five staple crops; corn, wheat, cotton, cattle and hogs, only in outside markets, and for these things they receive the market price less the freight.

To quote a few specific examples: Oklahoma has enough salt water going to waste to make 100 carloads of salt a day, yet all the salt used in the State comes from Kansas, Michigan and Louisiana. There is enough limestone in Oklahoma to burn all the lime that the world will ever use, yet practically all our lime comes from Texas, Arkansas and Missouri. With as good shale as any state possesses, practically all the brick, terra cotta and other clay products used are imported from Kansas and Missouri. Oklahoma has as good granite as can be found in the world, yet in our cemeteries are monuments, and in our large buildings, pillars and cap stones, made of granite from Scotland, Vermont, and Massachusetts, but practically none from Oklahoma. With the largest deposits of gypsum in the United States, a considerable amount of our gypsum plaster comes from Kansas and Texas. With Portland cement rock enough to supply cement for all the world, and fuel in abundance for its manufacture, we have but three cement plants, and much of the material we use comes from Kansas or Texas. With enough native asphalt in our hills to pave all the streets of all our cities, the greater part of our street paving is being done with the burned-out residue from the oil refineries. There is in Oklahoma but one cotton mill, but three glass factories, and six small oil refineries. We manufacture no shoes and but little clothing. Within the last year, two packing plants have been established in Oklahoma City. There are a few canning factories in various parts of the State, and most of the towns of any size have creameries.

It is safe to say, however, that at the present time, not 10 per cent of the materials used for building, food or clothing by the people of Oklahoma, are manufactured in the State. There is no state in the Union where opportunities are better, where greater returns may be made on investment, or where the people are more willing and anxious to give support to legitimate manufacturing industries. We appreciate the fact that the lack of these industries is a part of pioneer conditions. We accepted these conditions when we came to the new country, but because we were willing to accept them, is no reason, in itself, why we should always be willing to live under them. As soon as plants and factories are established, and mines and quarries opened, and the workmen necessary to carry on these industries are here, our farmers will be able to raise a still larger variety of crops and will receive a higher price for the products of the farm.

EDUCATION

No southern state has a greater number of state schools than has Oklahoma. The head of the educational system is the State University at Norman. The Agricultural and Mechanical College is at Stillwater, and in addition there are six district agricultural schools. Six state normal schools are located respectively at Edmond, Alva, Weatherford, Tahlequah, Durant and Ada. There are university preparatory schools at Tonkawa and Claremore, and a girls' industrial school at Chickasha. Agriculture and domestic science are taught in all the common schools of the State. Most counties now have consolidated rural schools. The work done in the high schools is up to the standard. The requirements for admission to the freshman class of the state University of Oklahoma, are with a single exception, higher than for any other southern university. Graduates from the University of Oklahoma take rank along with those from any institution in America.

THE PEOPLE

In opening a conversation with a stranger in Oklahoma it is not necessary to talk about the weather. The proper thing is to ask "Where are you from?" We're all from somewhere. The oldest native has been voting less than a year. Oklahoma is a meeting place for the clans. The northern farmer and the southern planter live side by side. The southerner harvests a wheat crop each year and the northern man is learning to grow cotton. The descendant of the Puritan and Cavilier vote at the same precinct. The grandchildren of Sam Houston and the offspring of Daniel Boone ride to town in the same automobile. Different traditions, different ideas, different view points, mingle and commingle, yet out of the turmoil and tumult of ideas and opinions there is arising a newer, greater and grander civilization.

Oklahoma is preeminently the young man's country. A man will make more advancement, attain a greater eminence in his profession or achieve greater success in business in five years in Oklahoma than in 20 years in one of the older states. We are not hampered by tradition nor have we any great respect for authority, as such. Precedent interferes with us not at all. We ask of a man one thing, and only one, namely, that he produce results.

We have no heroes; neither Clays nor Calhouns, Lincolns nor Lees. We are not interested in either heroes or ancestors but we are interested, intensely interested in the half million boys and girls growing up in our midst.

We have no past, and queerly enough we do not care for one. Oklahoma is a country with a future and we would rather live in a country with a future than one with a past.

In the older states a man, applying for a position, must be recommended, indorsed, vouched for, certified to, and analyzed, and not only he, himself, but his father and mother, brother and sister, his rich uncle, his maiden aunt, and all his numerous relatives, even unto the third and fourth generation. One of the best recommendations a young man can have in the East is that he belongs to one of the best families.

In Oklahoma conditions are entirely different. We assume that a man is a gentleman and a scholar, that his grandfather did not steal sheep, and that his maiden aunt did not elope with the coachman. We are not in the least interested in the family history. We ask a man two questions: First, "Can you do this work?" and, second, "Can you do it right now?" If so, well and good. If not, get out of the way, and let a man at it who can produce results.

This is the spirit that is today making Oklahoma great. This is the spirit that is at work among our people, developing farms, constructing railroads, building factories, and erecting sky scrapers. What we need is more men, more money. We are working as best we can, and the work is not always easy but we are not discouraged. We say to all the world, "Get out of the way and watch us grow, or, better still, come in with us and help us grow."

STATISTICS

The following statistics based on the most recent available data will indicate some present conditions, and something of the development of Oklahoma's resources.

	1900	1910	Per cent of Increase
Population	790,391	1,657,155	110
Population of two chief cities			
Oklahoma City	10,037	64 205	539
Muskogee	4,254	25,278	494
Cotton used, pounds		1,029,200	....
Cotton crop, bales	349,355	962,000	176
Corn, bushels	11,114,052	92,355,000	921
Wheat, bushels	18,657,373	25,363,000	56
Oats, bushels	....	23,068,000	....
Cattle	3,029,000	1,992,000	....
Swine	1,235,000	1,302,000	6
Mineral products, value	$3,000,000	$20,000,000	566
Coal mined, tons	1,922,298	2,700,000	42
Petroleum, barrels	....	55,000,000	....
Railroad mileage	2,399	6,106	154
Bank deposits	$9,000,000	$102,000,000	1033
Property, true value (exclusive of minerals)	$811,000,000	$1,200,000,000	48
Lumber cut, feet	22,104,000	226,000,000	921

Land area	70,470 square miles
Gypsum, tons, (estimated)	125,000,000,000
Glass sand, tons, (estimated)	100,000,000,000
Asphalt, tons, (estimated)	50,000,000,000
Natural gas, cu. ft. per day (estimated)	2,000,000,000
Granite, gabbro, limestone, marble, sandstone, clay, shale, building sand	Inexhaustible and widely distributed

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OKLAHOMA GEOLOGICAL SURVEY.

CIRCULAR NO. 4.

BUR-OAKS AND COTTONWOODS.

HE TREES AND SHRUBS OF OKLAHOMA.

By C. W. SHANNON.

NORMAN
March, 1913.

OKLAHOMA GEOLOGICAL SURVEY.

Governor Lee Cruce, State Superintendent R. H. Wilson,
President Stratton D. Brooks, Commission.

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C. W. Shannon	Field Geologist
Frank Buttram	Chemist

CIRCULAR NO. 4.

THE TREES AND SHRUBS OF OKLAHOMA.

By C. W. SHANNON.

NORMAN
March, 1913.

Who does his duty is a question
    Too complex to be solved by me
But he, I venture the suggestion,
    Does part of his, that plants a tree.
—Lowell.

He who plants an oak looks forward to future ages, and plant for posterity.—Irving.

THE TREES AND SHRUBS OF OKLAHOMA.

INTRODUCTION.

Scope of the Work.

Various phases of educational work come within the scope of the work of the Geological Survey of the State. The Survey originated as a Geological and Biological Survey of Oklahoma Territory. In the regular work of members of the Survey a large amount of material and information is gathered concerning the natural resources of the State. This information is given to the citizens of the State chiefly through articles in the papers, and by the publication of circulars and bulletins.

Early in 1912 the Geological Commission directed that a study of the trees of the State be undertaken at once. This work was assigned to the writer. The information so far collected has been secured while carrying on field work in connection with the regular work of the survey. This report is only preliminary. The work will be continued throughout the year along with other investigations, and it will be arranged to give a part of the year entirely to the work. Some consideration has been given to the trees and shrubs, and the condition of growth in sixty-six counties of the State. A preliminary list of the trees and shrubs was prepared and typewritten copies were furnished to a number of persons over the State, who were interested in gathering information concerning the trees. This list has proven to be in considerable demand and it is thought best to put it in more convenient form pending the publication of the final report. In the preparation of this work the writer has endeavored to give such general information as will make this report of value to the schools of the State, and to the public in general, until a more complete publication can be prepared.

In the present report the family, genus, scientific, and common names of the trees and shrubs are given, and in addition are notes on the general and specific occurrence of each plant included in the report. The names of a few vines and other plants having a close relation and association with the trees are given. An herbarium is being prepared of all the native plants included in the list. A large number of photographs of the trees have been taken and many of these will be used in the complete publication. Any additions, corrections, or suggestions will be gladly received.

Previous Work and Publications.

There is no person in the State who is making tree study or forestry his business. To the present time nothing has been published which can be called a catalogue of the trees or other plants of Oklahoma. There has been very little published which will give any information as to the part of the State in which certain plants may be found.

In the Second Biennial Report of the Department of Geology and Natural History, Territory of Oklahoma, for 1901-1902, Dr. A. H. VanVleet, head of the Department of Botany in the State University, gives a list of "Plants of Oklahoma." This list gives only the scientific names and includes about 1,000 plants of the Territory which were then in the herbarium of the department. The herbarium was later destroyed by fire. The list includes about sixty trees and shrubs.

In the Transactions of the Kansas Academy of Science, Vol. XVIII, 1901-1902, there is a short paper by Dr. C. N. Gould, entitled "Notes on trees, shrubs, and vines in the Cherokee Nation." This article includes the names of about 50 plants which occur in the Cherokee Nation.

In his "Geography of Oklahoma," Dr. Gould gives the occurrence and distribution of a number of trees and other plants. This work has proved of great value to the schools of the State, and has been the only available information along this line for the general public.

Value of Tree Study.

The rapid destruction of the forests in our country called the attention of students of forestry to the dangers which confronted us. The rapid development of the agricultural and industrial interests of the country has been accomplished by a sacrifice of our forests. At the present time people have been brought to a realization of the importance of systematic effort to prevent further devastation.

Forestry laws are being passed and many forest reserves have been formed. The United States now has reserves amounting to 50 million acres. Arbor Day observance is being instituted throughout the states, the prime object of which is the planting of trees for the beautifying of public and private grounds, and highways. Many universities and agricultural colleges have put in courses in forestry, and several schools of forestry have been established. The movement has reached the high schools and common schools, and farmers and owners of forest lands are giving their attention to the work.

It is of special importance that a careful study be made of our native trees, both from a scientific and an economic point. The general neglect and failure to ornament school grounds by the planting of trees and flowers has not escaped notice. School grounds should be made the most attractive places possible.

One of the problems in our tree study is to discover what trees may be transplanted and grown in the treeless parts of the State. The inhabitants desire shade and it is important that trees be secured which will meet the conditions. This problem will receive special attention in the final report.

A LIST OF THE TREES AND SHRUBS OF OKLAHOMA.

Sub-kingdom SPERMATOPHYTA.

SEED-BEARING PLANTS.

CLASS I. GYMNOSPERMAE.

NAKED SEEDS.

The Gymnosperms are an ancient group of plants. They are found among the fossils of the Silurian age, and are most numerous in Triassic time. They are now repersented by about 450 species of trees and shrubs. They are flowering plants in which the ovules, or seeds, are not inclosed in an ovary, but are borne naked upon an open scale. This scale is a modified leaf. The plants have a resinous juice, and chiefly parallel-veined, needle-shaped, or scale-like evergreen leaves. By far the larger number of the Gymnosperms are Coniferous (Pinaceae or Coniferae including some shrubs) or cone-bearing trees, the fruit being called a cone because of its form. This family of the class is the only one represented in our area.

PINE FAMILY. PINACEAE.

PINES. CONIFERS.

Pinaceae. Coniferae.

The trees belonging to this family are commonly known as Evergreens, because with the exception of the Larch and the Bald Cypress they do not shed their leaves during the winter. The Pines are a survival from the Devonian age. They were contemporaries of the Lycopods, the Sigillarids, and the Cycads which constitute the chief remains of vegetation found in the coal measure formations. The Pines still retain the simplicity of floral structure which was characteristic of the vegetation of early times. The fertilization of these trees depends upon the wind.

THE PINES. Genus PINUS.

The name is a Latin word from Celtic *pin* or *pen, a crag.*

The Pines are evergreen trees with two kinds of leaves, the primary ones scale-like, deciduous, the secondary ones narrow linear, needle-like, in group of 2-5 united at the base by the bud scales. There are about 35 species found in the United States. Many of these are of the greatest economic value. In our area at least two are known as natives.

LOBLOLLY PINE. OLD FIELD PINE. ROSEMARY PINE.

Pinus Taedea.

Taeda, the torch, was the classical name of a resinous pine tree.

This tree grows with a tall straight trunk, from 60 to 100 feet in height. The leaves are in clusters of threes, slender and stiff. Found in the southeastern part of the State from the lowlands to the uplands. In places the small growth is abundant.

YELLOW PINE. SHORT-LEAF PINE. NORTH CAROLINA PINE. SPRUCE PINE.

Pinus echinata.

L., *echinatus,* prickly; from *echinus,* a hedge hog.

A valuable timber tree, reaching the height of 75 to 100 feet or even more. The leaves are borne in clusters of 2, and occasionally 3, rarely 4, varying in length from 3-5 inches. This tree is very common, and in places makes up almost the entire forest area, in the eastern part of the State south of the Arkansas River.

Other varieties of pine may be found in the pine region of the eastern part of the State. The pines of the State have produced much valuable timber for interior work and general construction work. In the northern part of the area the pine timber is sparsely scattered, and does not attain a very large diameter. To the southward it increases in abundance and in size. Much of the rough stony land, as well as parts of the lowlands originally had a heavy growth of a good quality of pine. There are very few areas that have not been cut over. For the most part the remaining trees are under 14 inches in diameter, except where the trunks of the trees show injury from disease or fire, and have been passed by in the work of the lumberman.

SOUTHERN OR BALD CYPRESS. DECIDUOUS CYPRESS.

Taxodium distichum.

Taxodium, from the Greek indicating the resemblance of the leaves to those of the Yew tree.

The cypress grows in swamps and along streams from Delaware to Florida, along the coast and in the Mississippi Valley as far north as Southern Indiana. The cones are round, hard, closed, 1 inch in diameter. The leaves are deciduous.

The trunk of the tree spreads at the base and is ridged. Conical shaped projections called "knees" grow up from the roots. This tree is common in the southeast corner of the State in the Red River Flats and along the tributaries extending to the north through McCurtain County. Some trees of large size are found.

RED CEDAR. COMMON CEDAR. JUNIPER.

Juniperus Virginiana.

Juniperus, classical Latin name of the *Juniper.*

Evergreen, varying from a shrub to a high tree. It is readily distinguished from any other tree. The wood is very valuable. It is found throughout this State, probably with the exception of the extreme west and northwest. It varies from a small snarly shrub on rocky cliffs to fairly large trees 50 feet or more in height. It is also largely grown for ornament and wind protection. A fungus growth known as Cedar Apple is found on many of the trees. This fungus attacks the young twigs.

JUNIPER. GROUND CEDAR.

Juniperus communis.

Evergreen, varying from a low spreading shrub, to a small tree. It is a very widely distributed tree in the United States, but in Oklahoma, it occurs only in the extreme west and northwest part of the State.

ARBOR VITAE. WHITE CEDAR.

Thuja occidentalis.

Thuja is of Greek derivation, meaning, to sacrifice, the wood having been used in sacrifical offerings, because of its agreeable odor. *Occidentalis*, western, Arborvitae, Tree of Life, is supposed to have been given because the bark and twigs have been used in medicine.—Harriett L. Keeler.

The Arbor Vitae is a native of the northeastern United States and southeastern Canada. Many trees still of small size are found throughout Oklahoma where they have been planted for ornamental purposes. Several nursery varieties are planted. It grows well and is a very desirable tree to plant for the evergreen variety.

OTHER TREES OF PINE FAMILY AND ITS ALLIES.

Some small varieties of pine, and a considerable number of spruce, hemlock, and fir are being grown about lawns, city parks, and other public grounds over the State. The Gingko, a naturalized Chinese tree, belonging to the Yew family, has not been tried in this

State, to the knowledge of the writer, but is successfully grown neighboring states, and should be used as an ornamental tree in t State. It is a very beautiful tree. The leaves resemble those of maiden hair fern. They are not evergreen but turn yellow and d in late autumn, in this respect resembling the Bald Cypress.] nut contained in the fruit is edible when roasted.

CLASS II. ANGIOSPERMAE.

ENCLOSED SEEDS.

The class, *Angiospermae,* includes all the flowering plants exc the pines and their allies. The plants of this class are of more rec origin than those of the *Gymnospermae.* The ovules, or seeds, borne in a closed cavity, the ovary. The ripened ovary and its herent parts constitute the fruit.

This class is divided into two sub-classes, viz., *Monocotyledons* : *Dicotyledons.* The former division includes those plants in which embryo contains a single cotyledon, or seed-leaf, the first leaves ing alternate, the leaves are parallel veined, the parts of the flov are in 3s, the stem shows no distinct divisions into wood, pith, : bark; and the wire-like fibers of woody tissue (fibro-vasc bundles) are promiscuously distributed through the stem. The c stalk is an illustration of this kind of stem. Among trees the] metto of the Southern states is a representative of this class. ' *Dicotyledons* are plants in which the embryo contains two cotyled The leaves are mostly netted veined, the flowers are usually 4 (parted and the stem is divided into bark, wood, and pith. This s class includes the greater part of the flowering plants, including the trees of the northern temperate region except the *Gymnosper*

MAGNOLIA FAMILY. MAGNOLIACAE.

Magnolia was the name given to this family of plants by Linnaeus in h of Pierre Magnol, an eminent botanist of the 17th century.

To the knowledge of the writer, the Magnolias have not b found native to this State, but since several species occur in Ark sas and Texas, in the lowlands and adjacent hill sides near the O homa border, some varieties may be found native in the swamps wet soils of the southeast corner of the State. Several varieties grown for ornament, especially in the southeastern part fo the State. They are to be recommended very highly for such purposes.

Genus LIRIODENDRON.

TULIP TREE. YELLOW POPLAR. TULIP POPLAR.

Liriodendron tulipifera.

Liriodendron, from the Greek meaning lily and tree. *Tulipifera,* tulip-bearing.

This tree is not a native of this State, as its range is confined to the states east of the Mississippi. A very few of these trees have been planted in the State. It is a very suitable tree to plant, for lawn and park. A good rich soil is required for good growth. Both the leaves and the flowers, as well as the shape of the tree make it a very desirable tree. It may be grown from the seed or cuttings and is readily transplanted.

CUSTARD APPLE FAMILY. ANONACEAE.

Small trees and shrubs of many species, chiefly tropical or subtropical. Two genera only are represented in North America, one in southern Florida and the West Indies and the other in the United States, chiefly in the western part.

THE PAPAWS. Genus ASIMINA.

Asimina, Latin form of the Indian name *asimin,* for *Papaw.*

COMMON PAPAW.

Asimina triloba.

Triloba, refers to the flower.

Found in the eastern part of the State, not widely distributed. In some localities in thickets. Fruit large and edible. Flowers not conspicuous, dull, purple, and with disagreeable odor. Suitable for ornamental purposes and planting in groves. There is a yellow and a white fruited variety.

TAMARISK. TAMARISCINEAE.

The *Tamarisks* are sub-evergreen, shrubs or small trees, with very small pinkish flowers, in spike like clusters, or thickly grouped along the slender drooping branches. The leaves are very small and scale like. There are several species in cultivation, and numerous names have been applied by nursery men. A minute study of the flowers is necessary to determine the species. These plants have a tendency to grow in the form of spread out shrubs, but can be trained tree-like. Many of the members of this family are found growing escaped from cultivation about old building places. Some of the varieties are now being used to considerable extent for hedges about lawns and gardens. They continue to bloom through a good part of the growing season, and the forms with drooping branches are very beautiful.

MALLOW FAMILY. MALVACEAE.

The *Hibiscus* or *Rose Mallows* comprise a large family of mainly herbaceous plants with large holly-hock-like flowers. There is but one cultivated species in this region which has woody structure and tree-like appearance. This is the *Shrubby Althea* or *Hibiscus Syriacus* commonly called *Tree Hibiscus* or *Rose of Sharon*. This was originally introduced from Syria. There are many varieties with single or double flowers of many colors,—white, pink, red, purple, and variegated. A large number of these have been planted for ornament over the State and some have been observed which had reached a height of 15 to 20 feet.

LINDEN FAMILY. TILIACEAE.

About 20 species of this family are known, but not more than six are among the trees of the eastern part of North America. They are not found in western America.

THE LINDENS or BASSWOOD. Genus TILIA.

BASS WOOD. WHITE WOOD. LINDEN. LIME TREE.

Tilia Americana.

Tilia, the ancient classical name for *Linden*. Basswood has reference to the use of the inner bark for mats and cordage.

This tree is a native of rich woods, and grows to large size in much of its range. In the lower Ohio Valley, it becomes 130 feet in height, but the ordinary height is about 70 feet. It is a tree of great economic importance. The wood is soft and white; the inner bark very fibrous and tough. Its range extends through the eastern half of Oklahoma, but it is not abundant, but is found scattering here and there in the areas of good soil. It is also in cultivation in the State. Another tree probably a variety of the above is found in cultivation. This is *Tilia pubescens*, small leaved Basswood. Several introduced species and nursery varieties are much valued for their dense foliage, odd shaped leaves and slender branches.

RUE FAMILY. RUTACEAE.

This group comprises a large number of plants in warm regions. Of the trees not more than two or three will be found native to the State.

THE PRICKLY ASHES. Genus XANTHOXYLUM.

Xanthoxylum from two Greek words meaning *Yellow Wood.*

Trees and shrubs of a large number of species, five of which are found in the United States.

PRICKLY ASH. TOOTH-ACHE TREE.

Xanthoxylum Clava-Hercules.

This tree of small size has been reported as occuring in the southeastern corner of the State, but has not been found by the writer. The peculiar color and appearance of the bark are very characteristic "This is smooth and studded with scattered barnacle-like corky bossess each tipped with a thick sharp spine which, however, finally falls away. A fancied resemblance in these spiked trunks to the club of Hercules has suggested its specific name, and the hooked spines of its branches has given it its apt colloquial names, *"Wait-a-bit"* and *"Tear-blanket,"* while its pungent bark has given it the name *"Sting-tongue"* among the southern negroes. This property, too, as a source of relief in tooth-ache has caused it to be known as *"Tooth-ache Tree."*
—Hough.

THE WAFER ASHES. Genus PTELEA.

Small trees and shrubs. Five or six species are native to United States and Mexico. Only one grown tree-like, but it is wildly distributed.

WAFER ASH. HOP-TREE. SHRUBBY TREFOIL.

Ptelea trifoliata.

Ptelea, from the Greek, classical name of the elm and applied to this genus because of the elm like fruit. *Trifoliata,* the three parted compound leaf.

This shrub often growing with the true shape of a tree never attains a height of more than a few feet (6-10). The fruit resembles that of the elm but is larger. The fruit and the compound leaf of three leaflets readily characterizes this tree. It is known to occur from the east side to as far west as Alva in Woods County.

Genus PHELLODENDRON.

CHINESE CORK TREE.

Phellodendron Amurense.

An introduced tree with compound leaves resembling those of the

Tree of Heaven. The cork tree is being planted in some of our city parks, and grows fairly well.

MELIA FAMILY. MELIACEAE.

Tropical trees including the Mahogany.

Genus MELIA.

CHINA-TREE. CHINA-BERRY TREE. PRIDE OF INDIA.

Melia Azedarach.

A tree introduced from Persia. It is now planted throughout as a shade tree. It is quick growing and has a good shape. It does not seem to be well adapted to drouth conditions, as it was observed that many trees of this species died as a result of the excessively dry season of 1911. Sprouts grow up rapidly from the stumps of trees, note being made of four such sprouts which attained a height of 6 to 8 feet during growing season 1912. The fruit is globular, about the size of cherries, greenish yellow when ripe, remains on through the winter.

QUASSIA FAMILY. SIMARUBACEAE.

A group of introduced trees and shrubs, represented by a single tree in our area.

Genus AILANTHUS.

TREE OF HEAVEN. PARADISE TREE. CHINESE SUMAC.

Ailanthus glandulosus.

Ailanto, Tree of Heaven, *Glandulosus,* refers to the characteristic glands on the leaves.

This tree was originally introduced from China and Japan, but it is now widely cultivated and naturalized. It is found growing wild in many places having escaped from cultivation. It is a very rapid-growing tree and hardy throughout. At all times of year it has a good appearance and is well adapted for shade and ornamental purposes. The leaves are very large, compound, 2 to 5 feet long. In many cases especially on young trees, the leaves have as many as 60 leaflets. The fruit grows in clusters, is broadly winged, with the seed in the center.

This tree may be grown readily from root cuttings or from suckers which grow up from the roots. Only a part of the trees have fruit, as some have only staminate flowers. These staminate flowers are very ill scented and only the pistillate trees should be used. Great care should be taken in this regard in securing roots or suckers for planting.

HOLLY FAMILY. ILICINAE.

Theophrastus and other Greek authors named the Holly, *agria*, meaning wild or of the field. The term *aquifolium* is also applied from, *acutum*, sharp, and *folium*, a leaf. The name Holly is probably from the word "holy" since some writers speak of it as the Holy Tree.

THE HOLLIES. Genus ILEX.

Ilex from the resemblance of its leaves to the true Ilex of Virgil,—the *Holly Oak.*

AMERICAN HOLLY. CHRISTMAS HOLLY.

Ilex apaca.

This holly is found over a limited area in the southeast corner of the State.

SWAMP HOLLY. DECIDUOUS HOLLY.

Ilex decidua.

Abundant in southeast part and to be found scattering through eastern third south of Arkansas River. Noticeable because of the red fruit, 1-4 inch in diameter, ripening in autumn and persisting until spring. Branches silvery gray.

INK BERRY.

Ilex glabra.

A shrub 3-6 feet high in sandy lowlands and edges of sand hills along rivers in central part of State.

STAFF-TREE FAMILY. CELASTRACEAE.

Trees, shrubs, and vines of a large number of species.

Genus EUONYMUS.

The genus name is the classical Greek of a European species.

WAHOO. BURNING BUSH. SPINDLE TREE.

Euonymus atropurpureus.

Euonymus, from the Greek, signifying of good repute.

Atropurpureus, dark purple, pertaining to the flower.

A shrub, usually growing from two to six feet. In Arkansas and Oklahoma it often grows tree-like and reaches a height of from 10-20 feet. To be found throughout the tree growing area, and very common in some localities, for example along the Canadian River west of Norman. The name burning bush is from the bright colored fruit which remains long after the leaves have fallen. The Indians called the plant Waahoo, and used the wood in making arrows.

Genus CELASTRUS.

BITTER SWEET. WAXWORK.

Celastrus scandens.

Common throughout. Usually growing as a vine, sometimes as a shrub, often so in cultivation.

SOAPBERRY FAMILY. SAPINDACEAE.

A group of trees and shrubs represented by one species in our area.

Genus SAPINDUS.

SOAPBERRY. WESTERN SOAPBERRY. WILD CHINA TREE.

Sapindus Drummondi.

Name, *Sapo Indicus,* Indian Soap, from the soapy quality of the berries.

A small tree common throughout the State, except extreme northwest. Rare in some localities. Easily distinguished by its clusters of fruit remaining more or less shrivelled, on the tree until spring. The largest tree observed was in the Grand River Valley and was 10 inches in diameter and more than 30 feet high. Often a large number of the trees are found growing together.

HORSE-CHESTNUT FAMILY. HIPPOCANTANACEAE.

Trees and shrubs with compound leaves. Fruit large, leathery coated, often rough with one or more large chestnut-like but bitter seeds.

Genus AESCULUS.

COMMON HORSE CHESTNUT.

Aesculus Hippocastanum.

Aesculus, from *esca,* nourishment. *Hippocastanum,* from *hippos,* a horse, and *castanea,* a chestnut.

Found native in the northeast part of the State and in cultivation. Leaves of 7 leaflets. Very common in Grand River bottoms.

OHIO BUCKEYE. SWEET BUCKEYE. FETID BUCKEYE.

Aesculus glabra.

Glabra, smooth, referring to fruit when mature.

Northeast part of State, and in cultivation. Leaflets 5 to 7.

YELLOW BUCKEYE. SWEET BUCKEYE.

Aesculus octandra.

Eastern part. Leaflets 5, occasionally 6 or 7. This variety is also grown for shade and ornament. The buckeyes make very desirable trees for parks and lawn. There are several small varieties on the market.

Genus KOELREUTERIA.

Koelreuteria paniculata.

A cultivated tree from China. Hardy throughout. Leaves compound, with many leaflets, irregularly toothed. Fruit a three celled bladdery pod. An excellent tree for lawns and parks.

MAPLE FAMILY. ACERACEAE.

Trees with watery and saccharine sap. Include a large number of species and are widely distributed.

THE MAPLES. Genus ACER.

Acer, classical name of maple tree.

There are about 100 species of maple, of which about a dozen are found in North America. Several are of value for the sugar which can be made from the sap and most of these are valuable timber trees.

SILVER MAPLE. SOFT MAPLE. WHITE MAPLE. RIVER MAPLE.

Acer saccharinum.

Native to central and eastern part of State and extensively cultivated throughout. A good shade tree, making a rapid growth. Bark smooth on young trees, on old trees very flaky.

RED, SCARLET or WATER MAPLE. SWAMP MAPLE.

Acer rubrum.

In swamps and low grounds in east side of State. A good tree for cultivation but not commonly used.

HARD MAPLE. SUGAR or ROCK MAPLE. SUGAR-TREE.

Acer saccharum.

The common sugar maple. The most valuable one of the maples for the making of maple sugar. Is found in the eastern side of the State. Common in the Grand River Valley.

BLACK MAPLE. SUGAR MAPLE.

Acer nigrum.

Found growing with the Rock Maple. Leaves not so deeply or sharp lobed. Both varieties are excellent for shade but are rarely used in this State.

BOX ELDER. ASH-LEAVED MAPLE.

Acer negundo.

Native to a large part of the State and common in cultivation. Grows well and makes a good shade tree.

THE NORWAY MAPLE, *acer platanoides* and **CUT LEAVED JAPANESE MAPLE,** *acer palmatum,* are in cultivation, but so far have not made very successful growth, in the localities where planted.

BLADDER-NUT FAMILY. STAPHGLEACEAE.

AMERICAN BLADDER-NUT.

Staphylea trifoliata.

Occasionally found in the northeastern part of the State in moist shaded woodlands.

CASHEW FAMILY. ANACARDIACEAE.

A family of trees and shrubs represented in our area by one genus.

THE SUMACHS. Genus RHUS.

Rhus, from a Celtic word meaning red. *Sumac,* from the Arabic, *Sumaq.*

Shrubs often growing tree-like. The plants have a milky juice, compound leaves, fruit small, drupes in clusters.

SMOOTH SUMAC. UPLAND or SCARLET SUMAC.

Rhus glabra.

Common throughout the State except extreme west and northwest.

DWARF. BLACK or MOUNTAIN SUMAC. UPLAND SUMAC.

Rhus copallina.

Common over the State except extreme west and northwest. In many places covering large tracts with dense growth.

POISON SUMAC. POISON DOGWOOD. POISON ELDER.

Rhus Venenata.

Has been reported for eastern side of State. This plant is very poisonous to the touch.

CUT-LEAVED SUMAC.

Rhus lacinata.

Few in cultivation in public grounds.

ILL SCENTED SUMAC. SKUNK BUSH.

Rhus trilobata.

Common as a very low shrub except far northwest corner. Barren, sandy and rock soils.

FRAGRANT or SWEET SCENTED SUMAC.

Rhus aromatica.

Found in eastern two-thirds of State.

POISON IVY. POISON OAK. CLIMATH. THREE LEAF IVY.

Rhus radicans.

Common throughout the State as a vine or shrub.

WILD or AMERICAN SMOKE TREE. CHITTAM WOOD.

Rhus cotinoides.

Grown for ornament and reported native northeast corner of State.

PULSE or PEA FAMILY. LEGUMINOSAE.

A large order of trees, shrubs and herbs. The fruit is a legume. All the representatives in this region growing as trees or shrubs are of importance for shade and ornamental purposes.

THE LOCUSTS. Genus ROBINA.

The genus name is from Jean and Vaspasian Robin, herbalists, who first cultivated the Locust tree in Europe.

COMMON LOCUST. YELLOW LOCUST. BLACK LOCUST. SILVER CHAIN.

Robina pseudacacia.

Pseudacacia, false acacia or like the acacia.

Native in the east and central part of the State. Common throughout in cultivation for shade, especially along streets. In many places escaped from cultivation.

THE REDBUDS. Genus CERCIS.

JUDAS TREE. REDBUD.

Cercis Canadensis.

Common throughout except far western part of State. Grows as a shrub to small tree, reaches height of 20 feet. Excellent for lawn planting.

THE COFFEE TREE. Genus GYLMNOCLAUDUS.

The genus name is from two Greek words meaning ***naked branch.***

KENTUCKY COFFEE TREE. COFFEE-NUT.

Gymnocladus Canadensis.

Common throughout the State, except extreme northwest. Is good ornamental and shade tree.

THE HONEY-LOCUSTS. Genus. GLEDITSCHIA.

The generic name is in honor of J. G. Gleditsch, a German botanist 18th century.

HONEY LOCUST.

Gleditschia triacanthos.

Common in most parts of the State. Very common in cultiv tion. The wild form is usually very thorny. There is a varie without thorns in cultivation; also one with drooping foliage.

WATER LOCUST.

Gleditschia aquatica.

This locust may be found in the southeast corner of the State, but has not been observed by the writer.

ROSE FAMILY. ROSACEAE.

This family consists of trees, shrubs and herbs of more than 1,500 species and 90 genera. Ten genera are represented among the trees of the United States.

PEACHES, PLUMS and CHERRIES. Genus PRUNUS.

Prunus is the ancient Latin name for the Plum tree.

COMMON PEACH.

Prunus Persica.

Many varieties in cultivation. Often growing wild escaped from cultivation.

NECTARINE. SMOOTH SKINNED PEACH.

Prunus laevis.

In cultivation. It is a variety of the peach with smooth skin.

PIGEON CHERRY. PIN CHERRY. BIRD CHERRY. WILD RED CHERRY.

Prunus Pennsylvanica.

This tree is planted in a few places in the State for shade and ornament. It is also found escaped from cultivation. Is not native to the region.

WILD BLACK CHERRY. CABINET or RIVER CHERRY.

Prunus serolina.

Native to central part and east half of State.

AMERICAN PLUM. WILD PLUM.

Prunus Americana.

Widely distributed over the State in low places and along river banks.

WILD GOOSE PLUM. RIVER PLUM.

Prunus hortulana.

Native in the eastern part of the State.

CHICKASAW PLUM.

Prunus Augustifolia.

A shrub to small tree common throughout.

WATSON'S PLUM. SAND PLUM.

Prunus Watsoni.

LOW PLUM.

Prunus gracilis.

WESTERN SAND CHERRY. BESSY'S CHERRY.

Prunus Besseyi.

The last three named and others are among the low wild plums in various parts of the State.

CHOKE CHERRY.

Prunus Virginiana.

In many parts of the State in low, moist soils.

THE APPLES and PEARS. Genus PYRUS.

Pyrus is the ancient Latin for the pear.

COMMON APPLE.

Pyrus malus.

Hundreds of named varieties in cultivation. Orginally introduced from Europe.

AMERICAN or GARLAND CRAB. FRAGRANT CRAB.

Pyrus coronaria.

Found in central part and east half of State.

PRAIRIE CRAB.

Pyrus isensis.

Reported from east half of State.

SOULARD CRAB.

Pyrus soulardi.

Found in central part of east half.

AMERICAN or SMALL FRUITED ASH.

Pyrus Americana.

A good small tree for ornamental purposes now rare in cultivation.

ELDER-LEAVED or LARGE FRUITED MOUNTAIN ASH.

Pyrus sambricifolia.

Has been observed in central part of State in parks and college grounds.

COMMON PEAR.

Pyrus communis.

Several varieties in cultivation. The pear is a native of Europe.

Genus AMELANCHIER.

The genus name is from the popular name of the European species.

JUNE-BERRY. SERVICE-BERRY. SHAD BUSH.

Amelianchier Canadensis.

Reported from east side of State. Some in cultivation. Commonly called "Sarvis' berry.

THE HAWS or THORNS. Genus CRATAEGUS.

Crataegus is of Greek derivation and has reference to the strength of the wood.

GREEN HAW.

Crataegus viridis.

This haw is abundant in the Red River bottoms.

WASHINGTON THORN.

Crataegus cordata.

This is probably the one found throughout the eastern half of the State. Small fruit, red, remaining on tree late in winter. Many slender thorns.

DOTTED FRUITED HAWTHORN.

Crataegus punctata,

This one may be common but has been observed only on the ridges south of Sulphur in Platte National Park.

Genus RUBUS.

Includes the wild and cultivated raspberries, blackberries, and dewberries.

WITCH HAZEL FAMILY. HAMAMELIDEAE.

Genus HAMAMELIS.

The genus name was applied to a tree which blossomed at the same time as the apple tree. *Witch* is a modern spelling of the Saxon *wich* or *wych,* probably pendulous, drooping. Two trees are so named—the wich elm and wych hazel.—Harriett L. Keeler.

WITCH HAZEL.

Hamamelis Virginiana.

Found in central east side, north of Arkansas River. Largest observed was south of Marble City.

Genus LIQUIDAMBAR.

SWEET GUM. BILSTED. RED GUM.

Liquidambar styraciflua.

The genus name is derived from *liquidus* and the Arabic word *amber,* referring to the balsamic juices of the tree. *Styraciflua,* from the name of the ancient balsam.

This tree is found in the east side of the State south of the Arkansas River. It is abundant along the Poteau and the Kiamichi Rivers and their tributaries. It is a tree worthy of extensive cultivation.

GINSENG FAMILY. ARALIACEAE.

Genus ARALIA.

ANGELICA TREE. HERCULES CLUB.

Aralia spinosa.

The range of this tree would include the southeastern corner of the State, however, so far as known it has not been found. It is used for ornamental planting and is worthy of extensive use.

DOGWOOD FAMILY. CORNACEAE.

The name is from *cornu, horn* referring to the hardness of the wood.

THE DOGWOODS or CORNELS. Genus CORNUS.

FLOWERING DOGWOOD.

Cornus florida.

Throughout the eastern half of the State; increasing in abundance to the eastcentral part. Fruit red.

ROUGH LEAF or WHITE FRUITED DOGWOOD.

Cornus asperifolia.

Common over the State except far northwestern part.

THE TUPELOS. Genus NYSSA.

The genus name is that of a water nymph, and has been applied because of the water loving character of this species.

PEPPERIDGE. BLACK or SOUR GUM.

Nyssa sylvatica.

In eastern side of State. Some observed in Impson Valley 2-3 feet in diameter and 75 feet high.

HONEY-SUCKLE FAMILY. CAPRIFOLIACEAE.

Trees, shrubs and vines of about 300 species.

THE NANNY-BERRIES. Genus VIBURNUM.

RUSTY NANNY BERRY. SOUTHERN NANNY BERRY.

Viburnum rufidulum.

A shrub or small tree widely distributed over the State.

SMALL BLACK HAW.

Viburnum globosum.

Abundant in southeast corner, especially in Red River bottoms.

CRANBERRY TREE. SNOW BALL or GUELDER ROSE.

Viburnum opulus.

Cultivated for ornament, also growing wild about old building sites.

Genus SYMPHORICARPOS.

CORAL-BERRY.

Symphoricarpos Symphoricarpos.

Common throughout the State except extreme west and northwest.

WOLFBERRY.

Symphoircarpos occidentalis.

Found along rocky bluffs near Bromide Spring in Platte National Park.

Genus LONICERA.

TARTARIAN BUSH HONEYSUCKLE.

Lonicera Tatarica.

Grown for ornament. Many varieties.

HONEYSUCKLE.

Lonicera.

Many varieties in cultivation as vines or often trained as shrubs.

Genus DIERVILLA.

BUSH HONEYSUCKLE.

Diervilla diervilla.

In cultivation. Withstands drought well.

Genus SAMBUCUS.

AMERICAN ELDER. SWEET ELDER. ELDERBERRY.

Sambucus Canadensis.

Found throughout except probably extreme northwest.

SAPODILLA FAMILY. SAPOTACEAE.

Trees, shrubs and vines of wide distribution. One species produces gutta percha. All of the family grow in rather warm climates.

THE BUMELIAS. Genus BUMELIA.

Genus name is from the classical Greek for the *ash-tree.*

WOOLLY BUMELIA. CHITTIM WOOD. BUCKTHORN. GUM ELASTIC.

Bumelia languinosa.

A shrub to small tree 20 feet high common through eastern two-thirds of State. Fruit black.

BUCKTHORN FAMILY. RHAMNACEAE.

THE BUCKTHORNS. Genus RHAMNUS.

YELLOW BUCKTHORN. INDIAN CHERRY.

Rhamnus Caroliniana.

Found usually along streams and moist rich lands, occasionally in rocky uplands near heads of small ravines, widely distributed through the southeastern part of State, and rarely found throughout eastern half.

Genus CEANOTHUS.

NEW JERSEY TEA. RED ROOT.

Ceanothus Americanus.

A small shrub in the northeastern part of the State, observed along railroads. Has panicles of small white flowers.

EBONY FAMILY. EBENACEAE.

THE PERSIMMONS. Genus DIOSPEROS.

The genus name of Greek derivation, means the *wheat or fruit of Jove.* Persimmon is the Indian name.

COMMON PERSIMMON.

Diosperos Virginiana.

"When they are not fully ripe they are harsh and chokie, and furre in a man's mouth like alum, howbeit, being taken fully ripe, yt is a reasonable pleasant fruiet, somewhat luscious."

Common throughout. Most abundant in central part. A seedless variety was found by the writer, in Cleveland County along the Canadian River.

JAPAN PERSIMMON.

Diosperos Kaki.

A variety in cultivation. Leaves large, leathery and shiny. Fruit yellow, large. (2 inches diameter.)

STORAX FAMILY. STYRACACEAE.

THE SILVER BELL TREES. Genus MOHRODENDRON

Genus name in honor of Dr. Chas. Mohr, botanist, author of *"Flor Alabama."*

SILVER BELL TREE. SNOW DROP TREE.

Mohrodendron Carolinum.

The range of this tree covers the eastern part of the State, its occurrence has not been verified by the writer.

OLIVE FAMILY. OLEACEAE.

THE ASHES. Genus FRAXINUS.

The genus name is the ancient Latin name of the *ash-tree.*

WHITE ASH.

Fraxinus Americana.

Found in the east side of the State. Also grown for shade.

BLUE ASH.

Fraxinus quadrangulata.

Native in northeastern part and common in cultivation.

SWAMP ASH or WATER ASH.

Fraxinus platycarpa.

Found rarely in eastern half of State. Some in cultivation. very good for shade.

GREEN ASH.

Fraxinus viridis.

Native to eastern two-thirds of the State and extensively cu vated throughout.

FORESTIERA. Genus ADELIA.

ADELIA. FORESTIERA. SWAMP PRIVET.

Adelia acuminata.

Red River bottoms southeast corner of State.

PRIVET. Genus LIGUSTRUM.

PRIVET. PRIM.

Ligustrum Vulgari.

Many nursery varieties in cultivation used for ornament and hedges.

SYRINGIA. Genus SYRINGIA.

COMMON LILAC.

Syringia vulgaris.

Several varieties in cultivation. Often escaped from cultivation.

JAPAN LILAC.

Syringia Japonica.

Grown for ornament. Is a good flowering shrub.

Genus CHIONANTHUS.

FRINGE TREE.

Chionanthus Virginica.

Is found in cultivation in parks and public grounds. Is native to Arkansas and Texas.

FIGWORT FAMILY. SCROPHULARIACEAE.

Genus PAULOWNIA.

IMPERIAL PAULOWNIA. PAULOWNIA TREE.

A broad flat-headed tree, of rapid growth. A few are found in some of the city parks. It is a native of Japan. Is hardy throughout.

BIGNONIA FAMILY. BIGNONIACAE.

THE CATALPAS. Genus CATALPA.

The name is that given the American catalpas by the Cherokee Indians.

INDIAN BEAN. SOUTHERN CATALPA.

Catalpa bignonioides or *Catalpa catalpa.*

A tree native to the southern states. Is much planted in cultiva-on.

HARDY CATALPA. WESTERN CATALPA. CATAWBA TREE.

Catalpa speciosa.

A native of the central states. Widely planted throughout for shade, ornament and fence posts.

JAPANESE CATALPAS.

Catalpa Kaempferi and *Catalpa Bungei.*

Dwarf forms growing from 5 to 10 feet, umbrella shaped tops. Grown in cities and parks. Some in Oklahoma City and Muskogee.

LAUREL FAMILY. LAURACEAE.

BAY TREE. Genus PERSEA.

RED BAY.

Persea Borbonia.

A native of Arkansas and Texas and the southeastern states. Planted for ornament.

SASSAFRAS. Genus SASSAFRAS.

The name was applied by the early French settlers in Florida.

SASSAFRAS.

Sassafras sassafras or *Sassafras officinale.*

Common in the eastern third of the State, and in some localities in the east half, also, in cultivation. There is a variety with red wood and bark and a less common variety with lighter bark and white wood.

Genus LINDERA.

SPICE BUSH. BENJAMIN BUSH.

Lindera Benzoin.

part of the State in moist woodland soils. Goo
ly flowering in spring, and red fru

OLEASTER FAMILY. ELAEAGNACEAE.

Several members of the family in cultivation. A specimen of the **RUSSIAN OLIVE or OLEASTER**, was observed, which was at least 20 feet in height. The **DESERT WILLOW**, *chilopsis linearis,* from Texas is found in Oklahoma City. The **BUFFALO BERRY** or **RABBIT BERRY** has been found by the writer growing along the Canadian in the western part of Cleveland County.

NETTLE FAMILY. URTICACEAE.

THE ELMS. Genus ULMUS.

The genus name is the ancient name applied to the elm tree.

AMERICAN or WHITE ELM.

Ulmus Americana.

Common throughout the State, especially along streams. Extensively used for shade.

SLIPPERY or RED ELM.

Ulmus fulva or *U. pubescens.*

Throughout in moist soils. Much used for shade.

WAHOO or WINGED ELM.

Ulmus alata.

Very abundant as a shrub and tree in the eastern half of the State. Some trees as much as 14 inches in diameter and 50 feet high. In many places grows in thickets as shrubs or small trees.

Genus PLANERA.

PLANER TREE. WATER ELM.

Planera aquatica.

Probably found in the low lands of southeast corner.

THE HACKBERRIES. Genus CELTIS.

Celtis, the tree having been known to the ancient Celts.

SUGAR BERRY. HACKBERRY.

Celtis occidentalis.

Native to the eastern two-thirds of the State, more abundant central east part. Grown for shade throughout.

MISSISSIPPI HACKBERRY. SUGAR HACKBERRY.

Celtis Mississippiensis.

Native eastern two-thirds and cultivated throughout.

HACKBERRY.

Celtis Var?

At least two other forms of the hackberry have been found they have not been identified.

OSAGE ORANGE. Genus MACLURA.

OSAGE ORANGE. BOW-WOOD. BOIS D' ARC.

Toxylon pomiferum, or *Maclura aurantiaca.*

Toxylon, refers to the use of the wood in the manufacture of bows by dians. *Maclura,* given in honor of Wm. Maclure, a scientist.

Common in east third; abundant in southeast. Much grown hedge.

THE MULBERRIES. Genus MORUS.

RED MULBERRY.

Morus rubra.

Widely distributed in its native growth, and considerably u for shade.

WHITE MULBERRY.

Morus alba.

Grown for shade. The largest known in the State is in Norn This tree is a foot in diameter and 50 feet high.

RUSSIAN or BARREN MULBERRY.

A variety which does not produce fruit. It is extensively gr for shade. It is a rapid grower and a good tree to plant.

Genus BROUSSONETIA.

PAPER MULBERRY.

Broussonetia papyrifera.

Widely grown for ornament. Many varieties with droo branches, the *Weeping Mulberries.* Remarkable for the great va tion in the form of the leaves.

FRENCH MULBERRY.

Callicarpa Americana.

A shrub reported as occurring in the northeast corner of the State. Does not belong with Mulberry family.

PLANE-TREE FAMILY. PLATANACEAE.

Genus PLATANUS.

SYCAMORE. BUTTONWOOD.

Platanus occidentalis.

Platanus, from *platus,* broad, refers to the leaf.

Common along streams in eastern two-thirds. Recentyl being extensiely planted. The **ORIENTAL PLANE,** *Platanus orientalis,* an imported variety is probably better for shade.

WALNUT FAMILY. JUGLANDACEAE.

Juglans is from *Jovis, Jove's* and *glans,* a mast, or acorn.

THE WALNUTS. Genus JUGLANS.

BUTTERNUT. WHITE WALNUT.

Juglans cinerea.

Will probably be found in northeastern part of the State.

BLACK WALNUT.

Juglans nigra.

Common throughout the State. More abundant in some localities than others. There are at least two or three varieties if not different species. Difference in growth, size and appearance of fruit.

THE HICKORIES. Genus CARYA or HICORIA.

Hickory is derived from the Indian name of the liquor obtained by pounding the kernels.

Carya in honor of Carya, daughter of the King of Laconia, who was changed by Bacchus into a walnut tree.

BITTERNUT HICKORY. SWAMP HICKORY.

Hickory minima.

Found in east side of State.

WATER HICKORY. SWAMP HICKORY.

Hicoria aquatica.

Occurs in southeast corner, in Red River bottoms.

BIG SHELL BARK HICKORY. KING NUT.

Hicoria ovata or *Carya sulcata.*

East side in lowlands. Not abundant or widely distributed.

MOCKER-NUT HICKORY.

Hicoria alba or *Carya tomentosa.*

In eastern two-thirds, abundant especially on rocky and sandy uplands.

PIGNUT HICKORY.

Hicoria glabra or *Carya porcina.*

Throughout eastern third of State.

PECANS.

Hicoria Pecan.

Common except parts of far west and northwest parts of State. Along many of the streams in central part of State grows very abundant.

PALE-LEAF HICKORY.

Hicoria villosa.

Only in the extreme southeast corner.

WILLOW FAMILY. SALICACEAE.

THE WILLOWS. Genus SALIX.

PEACH or ALMOND-LEAF WILLOW. WESTERN BLACK WILLOW.

Salix amygdaloides.

Found along streams throughout the State.

LONG-STALKED WILLOW. WARD WILLOW.

Salix longipes.

Throughout the State.

BLACK WILLOW.

Salix nigra.

Common throughout the State. Some 50 feet high, 14 inches in diameter.

NARROW or LONG-LEAVED WILLOW. SAND-BAR WILLOW. RING WILLOW.

Salix longifolia or *S. fluviatilis.*

Found throughout the State. Very abundant along the sands of the Canadian and Cimarron. There is a variety with curly leaves in cultivation.

THE POPLARS. Genus POPULUS.

Populus, from *Pallo,* to shake or vibrate, or from Roman derivation, *arbor populi,* tree of the people.

WHITE POPLAR. ABELE TREE. SILVER-LEAF POPLAR.

Populus alba.

In cultivation in parks and lawns.

COTTONWOOD. NECKLACE POPLAR. CAROLINA POPLAR.

Populus deltoides.

Common throughout the State along streams and widely planted for shade.

WESTERN COTTONWOOD.

P. deltoides occidentalis.

A western form of the cottonwood, its range in the State is not determined.

LOMBARDY POPLAR.

Populus nigra Italica or *P dilatata.*

In cultivation to some extent throughout.

SWAMP POPLAR. DOWNY-LEAVED POPLAR.

Populus heterophylla.

In lowlands southeast corner of State.

LANCE-LEAF COTTONWOOD and NARROW-LEAF COTTONWOOD

Populus acuminata. Populus angustifolia.

These two poplars occur to the westward of the Panhandle of

Oklahoma about the heads of the streams which find their way int the State and it is very probable that some of these trees may b found in the far northwestern part of the State along the streams.

THE OAK FAMILY. CUPULIFERAE.

THE BIRCHES. Genus BETULA.

Betula, derived from bitumen. Birch is from *Betu* the Celtic name, or fro *batuere,* to beat.

RIVER BIRCH. WATER BIRCH. RED BIRCH.

Betula nigra.

Common along many of the streams in eastern half, chiefly smal growth; some large, fifty feet high, two feet in diameter.

EUROPEAN WHITE BIRCH.

Betula alba.

In cultivation under several names which indicate the characte of growth or foliage, as "Weeping Birch."

THE ALDERS. Genus ALNUS.

SEA SIDE ALDER.

Alnus maratima.

Along Red River and tributaries southeastern corner of State—

SMOOTH ALDER.

Alnus rugosa* or *A. serrulata.

Along streams and hillsides in eastern and southeastern part State. It was found growing high up in the hills north of Quinto

THE HAZELNUTS. Genus CORYLUS.

WILD HAZELNUT or COMMON HAZELNUT.

Corylus Americana.

Found in a limited area near the center of east side.

THE HORNBEAMS. Genus CARPINUS.

AMERICAN HORNBEAM. BLUE or WATER BEECH.

Carpinus Caroliniana.

Found in eastern part of State but not so common as the Iron wood.

THE HOP HORNBEAM. Genus OSTRYA.

IRON-WOOD. AMERICAN HOP-HORNBEAM.

Ostrya Virginiana.

Common along streams and hillsides eastern part of State.

THE OAKS. Genus QUERCUS.

Quercus probably from the Celtic words, *quer,* fine, and *cuex,* a tree. "Jove's own tree."—Virgil.

RED OAK.

Quercus rubra.

Found in east side of State.

SOUTHERN RED OAK. SCHNECK'S OAK.

Quercus Texana.

Common throughout in eastern third.

PIN OAK. SWAMP OAK.

Quercus palustris.

In east and northeast part of State.

YELLOW OAK. BLACK OAK. QUERCITRON OAK.

Quercus velutina.

Found in eastern half.

SPANISH OAK.

Quercus digitata, or *Quercus falcata.*

Found in east side and also in cultivation.

BLACK JACK OAK. BARREN OAK.

Quercus Marilandica or *Quercus nigra.*

Abundant in eastern two-thirds and in scattering clumps on sand hills further to west. The most abundant tree in the State.

WATER OAK. DUCK OAK. POSSUM OAK.

Quercus nigra or *Quercus aquatica.*

Found in east and southeast part of State.

WILLOW OAK.

Quercus Phellos.

East side south of Arkansas River. Very abundant in some localities.

SHINGLE OAK.

Quercus imbricaria.

Reported as occurring in northeast corner.

WHITE OAK.

Quercus alba.

In northeast part and east side. Not so common or widely distributed as most of the oaks.

POST OAK. ROUGH or BOX WHITE OAK.

Quercus minor or *Q. obtusiloba* or *Q. Stellata.*

In east half and irregular patches through central part and occasionally westward. The second most abundant in the State.

BURR OAK. MOSSY CUP OAK.

Quercus macrocarpa.

Eastern half and occasionally farther west. Found as far wes s Clinton.

OVER-CUP OAK.

Quercus lyrata.

Found eastern third, chiefly north of Arkansas River.

SWAMP WHITE OAK.

Quercus platanoides.

Near center eastern side.

COW OAK. BASKET OAK.

Quercus Michauxii.

Eastern half and irregular line into central part, extending northwestward.

CHESTNUT OAK. CHINQUAPIN OAK. YELLOW OAK.

Quercus acuminata or *Q. Muhlenbergii.*

Found in east half and occasionally westward.

LIVE OAK.

Quercus Virginiana.

Reported in southeast corner.

DWARF CHESTNUT OAK. SCRUB OAK.

Quercus prinoides.

At least two varieties of this oak occur in the State. One in the western part with coarsely toothed, bright green leaves, grows about 2-10 feet high, forms broad clumps. Common about Foss and Elk City. The other variety has very small leaves, wavy toothed, grows 2-6 feet. This one has been found only on top of ridge south of Sulphur in Platt National Park.

THE CHESTNUTS. Genus CASTANEA.

From *Castanea,* a town in Thessaly.

CHESTNUT.

Castanea sativa or *C. dentata.*

Occasionally one found in eastern part of State, in cultivation.

CHINQUAPIN.

Castanea pumila.

Reported along eastern margin. A dwarf form is found in cultivation.

THE BEECHES. Genus FAGUS.

AMERICAN BEECH.

Fagus Americana.

A small area in the east side of LeFlore County, near Holland.

HUCKLEBERRY FAMILY. VACCINICACEAE.

Genus BATODENDRON.

FARKLEBERRY. TREE HUCKLEBERRY. SPARKLEBERRY.

Batodendron arboreum.

Found in east side of State.

MADDER FAMILY. RUBIACEAE.

Genus CEPHALANTHUS.

BUTTON BUSH.

Cephalanthus occidentalis.

Widely distributed over the State from the lowest river bottoms to the highest mountain streams.

HYDRANGA FAMILY. HYDRANGEACEAE.

Genus HYDRANGEA.

WILD HYDRANGEA.

Hydrangea arborescens.

Occurs sparsely throughout the timbered area.

Genus PHILADELPHUS.

SYRINGA.

Philadelphus.

Several varieties in cultivation and in some places growing wild about old habitations.

GOOSEBERRY FAMILY. GROSSULARIACEAE.

Genus RIBES.

GOOSEBERRIES.

Ribes.

Several varieties of garden gooseberry.

SLENDER GOOSEBERRY.

Ribes gracile.

Rare in east part.

MISSOURI GOOSEBERRY.

Ribes Missouriensis.

Probably a variety found growing rare in east part.

THE COMMON CURRANTS in cultivation.

Ribes rubrum and *ribes nigrum.*

GOLDEN BUFFALO or MISSOURI CURRANT. CLOVE BUSH.

Ribes aureum chrysococcum.

In central part, probably widely distributed.

MISCELLANEOUS.

PRAIRIE MESQUITE.

Prosopis glandulosa.

Western part, known to occur as far east as Okarche.

FALSE or BASTARD INDIGO.

Amorpha fruticosa.

Widely distributed over the State.

LEAD PLANT. SHOESTRINGS.

Amorpha canescens.

Prairie lands central and western, very abundant.

TRUMPET FLOWER or TRUMPET CREEPER.

Tecoma radicans.

Throughout except west part. Grows as a vine or shrub.

AMERICAN MISTLETOE.

Phoradendron flavescens.

Parsitic principally on elm, also found on black gum, honey locust and bois d'arc. Widely distributed.

JC Branner

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5

ROCK ASPHALTS OF OKLAHOMA AND THEIR USE IN PAVING.

By L. C. SNIDER.

NORMAN
April, 1913.

OKLAHOMA GEOLOGICAL SURVEY

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INTRODUCTION.

This circular consists principally of two papers previously published in technical journals. The papers are "Rock Asphalt Deposits of Oklahoma" published in the *Mining and Engineering World* of March 22, 1913, and "Rock Asphalts of Oklahoma and their use in Paving" published in *Good Roads* of March 1, 1913. These journals have permitted the use of the articles for this circular. Some few paragraphs have been added to both articles. Further acknowledgment is due the *Mining and Engineering World* for the use of cuts for figs. 1, 2, 3, 5, and 6. H. I. Jones, (formerly of the Muskogee High School, now Professor of Chemistry of Dakota Wesleyan University, Mitchell, S. D.) made the analyses of the sheet and rock asphalt pavements and furnished a large share of the notes on the comparison of the rock asphalt and sheet asphalt pavements.

The most complete description of the asphalt deposits of the State so far published is contained in Bulletin No. 2 of this Survey. The edition of this bulletin is almost exhausted and this circular is issued as a source of information concerning the deposits until a final report can be prepared.

BRIEF DESCRIPTION OF THE DEPOSITS.

The asphalts of Oklahma with one or two exceptions, occur in the southern one-third of the state, from the Arkansas line westward nearly the length of the State, the westernmost occurrence being in the northwestern part of the Wichita Mountains. For convenience the area will be divided into districts beginning at the west as follows: The Wichita Mountains, Stephens and Jefferson counties, Ardmore district, Arbuckle Mountains, Ouachita Mountains, and Red River district.

The commercial deposits of asphalts of the Wichita Mountains occur in the vicinity of Lawton. They consist of sandstones saturated with asphaltic bitumen. One quarry near Elgin was worked for material for paving in Lawton some years ago, and has recently been reopened. Several other exposures are known, but they have not been sufficiently prospected to give anything definite as to the exact area, thickness or nature of the material. The Wichita district cannot, at present, be classed as important in the asphalt resources of the state in point of production but the amount of material is sufficient to make it of at least local importance.

Jefferson and Stephens counties contain considerable deposits of sandstone asphalt. In the northeastern part of Jefferson County 160 acres of segregated asphalt land is underlaid by a ledge of asphaltic sandstone 25 feet thick. This material has been shipped from Comanche and used for paving. Two other outcrops of similar material occur in the vicinity and may be part of the same bed. The Stephens County deposits are in the southeastern part of the county. In one instance at least, the asphalt appears to have worked up along a fault and to have impregnated the sandstone on either side. All the deposits are at some distance from transportation and have not been utilized, although there are large amounts of the material present.

The Ardmore district in Carter County is an important one, both in respect to the amount of asphalt present and to the amount of development. The asphalts occur in the Glenn formation of Pennsylvanian age, and those worked are impregnations of sandstone by asphaltic bitumen of varying consistency. The rocks are folded and the deposits of asphaltic sandstone usually dip very steeply, and in some cases are almost perpendicular. The amount of asphaltic sandstone in the district is impossible to estimate, and the known deposits number about 15. Brief descriptions of the four principal deposits are given below.

The Consolidated Sand quarry is located 5 miles south and 2 west of Ardmore, and 2 miles north and 1 west of Overbrook. The ledge is 25 feet thick and dips at an angle of 20°. The outcrop is one-half mile long. It is underlaid by blue shale and has an overburden of soil. The sandstone is massive, but shows lighter colored streaks due to variations in the percentage of bitumen. There are occasional nodules of clay through the deposit. The asphalt is used to give the solid pitch to paving mixtures. The material shows a fairly sharp, fine sand carrying about 10% of semi-solid sticky, ductile bitumen.[1]

The examination of this material gave the following results:

Locality	Ardmore.
Material	Rock Asphalt.
Bitumen soluble in CS_2	9.97 %
Character of bitumen—Semi-solid, sticky, ductile.	
Analysis of bitumen:	
Specific gravity 25°C/25°C	1.032
Penetration 100 g. 5 sec. 25°C	54.
Loss at 163° C. 5 hours	4.11 %
Consistency of residue, penetration as above	22.
Bitumen insoluble in 86° B. paraffin naphtha	22.44 %
Fixed carbon	10.22 %
Mineral matter	1.78 %
Grading of mineral aggregate:	
Retained on 50-mesh sieve	0.0 %
Retained on 80-mesh sieve	4.4 %
Retained on 100-mesh sieve	14.0 %
Retained on 200-mesh sieve	57.5 %
Passing 200-mesh sieve	24.1 %
	100.0 %

Character of mineral aggregate—a fairly sharp, fine sand.

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[1] The tests upon the asphalts were made by the U. S. Office of Public Roads, at Washington, D. C.

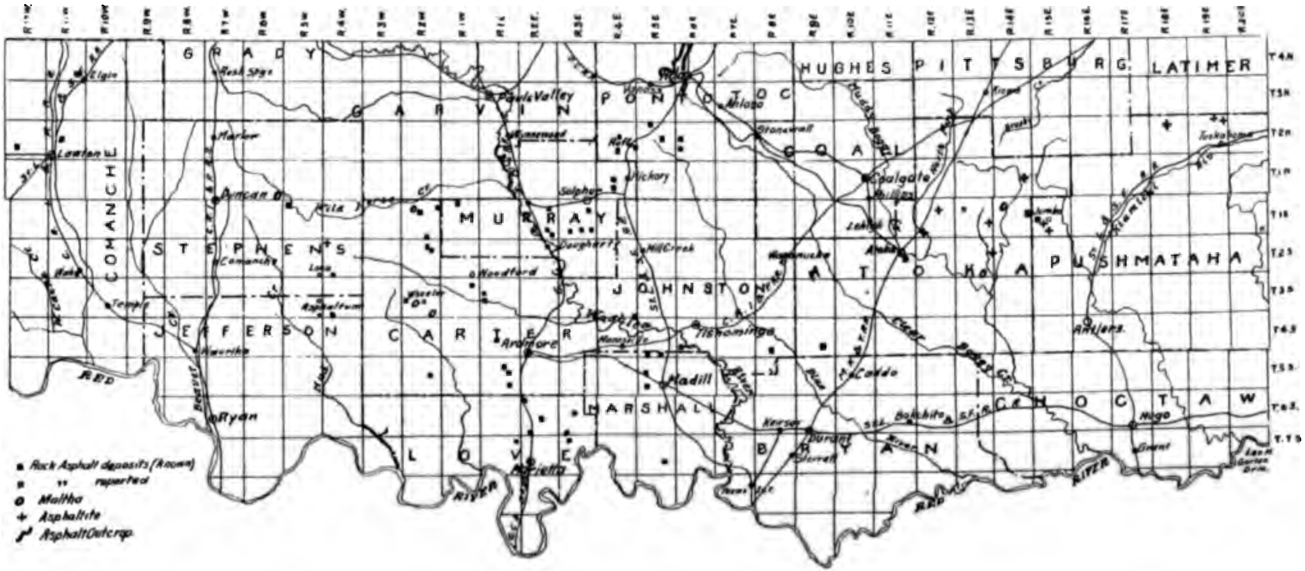

FIG. 1. MAP OF A PORTION OF SOUTHERN OKLAHOMA SHOWING PRINCIPAL ASPHALT DEPOSITS. (AFTER HUTCHISON).

Another deposit of consolidated sand lies 2 miles north of the one described. This ledge stands practically perpendicular, and is about 25 feet thick. The trend of the ledge is NW-SE. On the east side there is a wall rock of limestone 2 feet thick, and on the west a bed of conglomerate. There are occasional "horses" of clay and conglomerate which must be thrown out when the material is worked. The material is similar to that last described, and is reported to average 10 per cent bitumen. The product of both the consolidated sand mines is hauled to a spur track on the Gulf, Colorado & Santa Fe railway, about 2 miles distant.

The Aleck mine is located 12 miles northwest of Ardmore. A perpendicular ledge of 65 feet in thickness is separated from a second perpendicular ledge by a bed of shale. The deposit is broken occasionally by streaks of clay. The sand carries about 12% of heavy, viscous bitumen. The extent of the deposit is not known, but the ledge is exposed at intervals for one-fourth mile, and the material in sight may be said to be inexhaustible. A pit 60 by 60 feet has been opened without reaching the limit of the bed. The product is elevated by horse power cranes and is hauled by wagon to Ardmore. It is used as the flux in the paving mixtures.

Near Woodford, 9 miles west and 11 north of Ardmore, is an area of 1280 acres of segregated[1] land. The asphalt-bearing rock is a sandstone which contains an impregnated zone about 45 feet wide. The rocks stand almost vertically, and the impregnated zone outcrops for a distance of about a mile, and may extend much farther. The depth to which the asphaltic rock extends is unknown. This deposit has been worked to a considerable extent. The nature of the deposit and the workings are shown in the accompanying illustration showing the east end of the pit (fig. 2). The amount of material present is practically inexhaustible.

In the Arbuckle Mountain district, Murray, Johnston and Pontotoc counties contain commercial deposits of asphalt.

The deposits of Murray County are principally rock asphalts, and are impregnations of limestone and sandstone of Ordovician age. The deposits are confined to a relatively small area lying east of Dougherty and south of Sulphur. The area is divided into two districts, the Buckhorn and the Brunswick. Each of these districts contains several known deposits of which only a few will be mentioned.

The Moss quarry in the Buckhorn district is about 400 feet long and has been worked back about 300 feet from the outcrop. The material is a sandstone about 8 feet thick which carries 7 to 10 per cent. bitumen. The cover varies from 20 to 40 feet. Probably less than half of the deposit has been removed.

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[1] Segregated land is that which on account of its containing coal or asphalt deposits was set aside at the time of the allotment of the Indian tribes, and which remains the property of the Choctaw and Chickasaw tribes.

The report of the test of this material is as follows:

Locality	Murray County.
Material	Bituminous limestone.
Specific gravity	2.50
Weight per cubic foot	156. pounds.
Water absorbed per cubic foot	0.86 pounds.
Per cent. of wear	4.2
French coefficient of wear	9.6

Hardness—Not suitable for these tests.
Toughness—Not suitable for these tests.
Cementing value—Excellent.

Remarks: A rock of medium resistance to wear and excellent cementing value. Would probably make a very good road building material.

The No. 2 sand quarry is located on Rock Creek about a mile east of the limestone quarry just described. The development consists of a large circular pit, 35 feet deep, on the banks of the creek. The depth is reported to have been explored by the drill to 90 feet. The deposit is probably horizontal and has an overburden of 2 feet 10 feet of conglomerate and varying thickness of soil. The product consists of sub-angular grains of sand cemented by solid asphalt pitch having the penetration of ordinary asphalt cement. The product is hauled to Dougherty. It is used to furnish the solid pitch for paving mixtures.

The report of the tests on this material follows:

Locality	Dougherty.
Material	Rock Asphalt.
Bitumen soluble in CS_2	7.80 %

Character of bitumen—Semi-solid, sticky, ductile.

Analysis of bitumen:

Specific gravity 25° C/25° C	1.017
Penetration 100 g. 5 sec. 25°C	61.
Loss at 163° C. 5 hours	3.48 %
Consistency of residue, penetration as above	29.
Bitumen insoluble in 86° B. paraffin naphtha	22.44 %
Fixed carbon	10.36 %
Mineral matter	4.93 %

Grading of mineral aggregate:

Retained on 50-mesh sieve	0.2 %
Retained on 80-mesh sieve	9.8 %
Retained on 100-mesh sieve	14.3 %
Retained on 200-mesh sieve	45.1 %
Passing 200-mesh sieve	30.6 %
	100.0 %

Character of mineral aggregate—very fine sand with rounded grains.

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Only a small quarry has been opened. Near Franks, 480 acres of land containing limestone, shale and sandstone asphalts, some of them very rich in bitumen, have been segregated. The distance from transportation has prevented development.

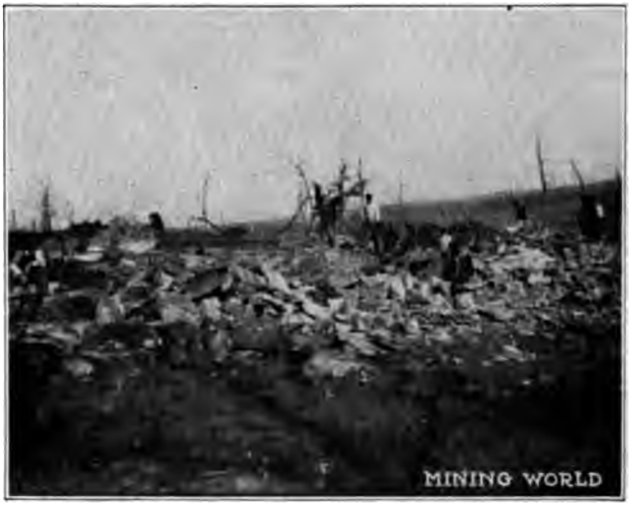

FIG. 5. OPENING AN ASPHALT QUARRY NEAR ADA.

Johnston County has only one deposit of asphalt in the Arbuckle Mountain region. This is at Ravia. A portion of the quarry is shown in fig. 6. The asphalt is a limestone, 5 to 6 feet thick, unevenly impregnated with bitumen. The material has been used in paving, but the quarry is not worked at present.

The asphalts of the Red River district occur principally in the Trinity sand, the basal formation of the Lower Cretaceous system. The rocks all dip very gently to the southeast and have remained practically unaltered since deposition. The sands of the Trinity are usually unconsolidated except where cemented by bituminous materials. The deposits of the Red River district are not so well developed nor so well known as those of the Ardmore and Arbuckle Mountain districts, and although they are of considerable importance can receive only brief notice here.

In Love County there are seven reported occurrences of asphaltic material, partly in the Trinity sand and partly in the Glenn formation. The only deposit which has been worked is southeast of Overbrook in the Glenn formation. Marshall County has seven reported occurrences, principally lenticular bodies in the sand. The deposits in the extreme southern portion of Johnston County seem to be quite extensive. One of these, a mile south and 2 east of Russet, is a layer near the top of the Trinity sand about 12 feet in thickness. The hill has an area of about 50 acres. The asphalt is overlaid by 10 to 20 feet of barren sandstone and 2 to 3 feet of limestone. The conditions of outcrop are shown in fig. 7. A similar deposit is found 3½ miles south, and 1½ miles west of Tishomingo. Bryan County contains some deposits of sand asphalt northeast of Durant, but nothing definite is known of their extent or character. One deposit in the Trinity sand occurs on the bank of Little River, near Idabel in McCurtain County, east of the area shown in the accompanying map. In general these asphalts are soft and seem to contain considerable paraffin. Their use in paving is questionable at present.

In the Ouachita Mountain region the only deposits of rock asphalt known are a few in Atoka County, and one in LeFlore County, which have not been prospected sufficiently to make any statements regarding their extent or value. The deposits of pure asphalt, grahamite at Jumbo near Antlers, and at Paige near Poteau, and gilsonite near Tuskahoma, are also in this region. The pure asphalts occur in veins, usually along fault lines. Some of these could be used for paving but they are more valuable for other purposes.

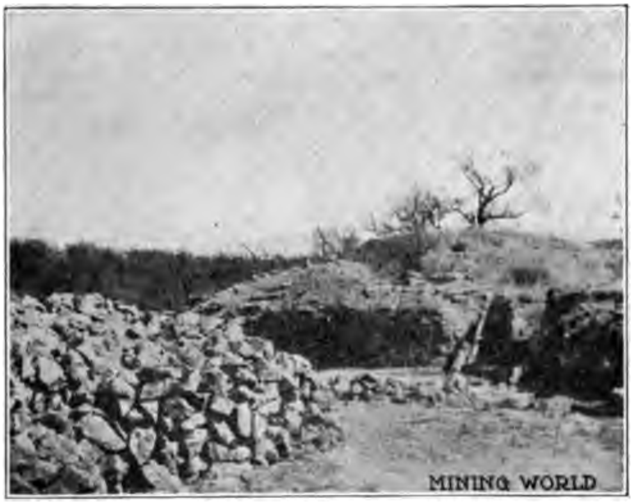

FIG. 6. PORTION OF ASPHALT QUARRY NEAR RAVIA.

THE USE OF THE OKLAHOMA ASPHALTS IN PAVING.

In spite of the abundant supply of raw material, the Oklahoma asphalts have not been used to any great extent for paving purposes and the idea seems to prevail that these asphalts are not suited for paving. It is well known that the asphalts used in paving in Europe are rock asphalts, the Seyssel limestone asphalt probably being the best known, but the Oklahoma asphalts are usually considered as belonging to an entirely different type.

The ideas in vogue concerning the Oklahoma asphalts are probably derived in large measure from the opinions expressed by Clifford Richardson in his book, "The Modern Asphalt Pavement." In chapter XII of this book he describes some of the deposits of Oklahoma and arrives at the following conclusions: "That the deposits, though large in amount are individually small, and moreover far from being uniform in their character, they contain too little bitumen and this bitumen is not sufficiently asphaltic in its character."

In speaking of the deposits of the Buckhorn district he says:

"Although fairly satisfactory pavements have been made with these materials it is not probable that they will prove of any importance in the paving industry as the supply as turned out is too small to permit of obtaining a requisite quantity of uniform quality and because the greatest skill is necessary in so handling the material as to make it possible to put it down with the bitumen in a proper state of consistency, as this changes very readily on being heated in the slightest degree to too high a temperature."

The points as given by Richardson, then, may be summarized as follows:

1. The small size of the individual deposits.
2. The lack of uniformity in character.
3. Small amount of bitumen content.
4. Non-asphaltic character of the bitumen.
5. Skill required to lay the pavement.

Since Richardson's work appeared the material has been used to a greater extent than before and the results seem to be at variance with his conclusions. In the following paragraphs the objections made by Richardson are considered in turn in the light of experience with the material in pavements.

In regard to the first point, two things must be considered, (1) That many of the individual deposits are much larger than any of those described by Richardson; (2) that, for use in paving, the products of two or more mines may be mixed together to form the surface mixture. One of the deposits of the Ardmore district is 45 feet wide, is known to be 1½ miles long and 100 feet deep. (See fig. 2). Both the depth and length may be, and the depth certainly is, much greater than this. Estimated on the basis of the known length and depth, this deposit contains about 2¼ million tons. Three other deposits in the same district contain together at least twice as much more and probably several times as much. A very conservative estimate of the known deposit at Ada (fig. 3) gives 13½ million tons. One of the limestone asphalt deposits is sufficiently large to supply any demands that may be made up on it for many years to come.

The smaller deposits are in clusters or districts and in many cases their products can be combined so that they are in all respects equal to a smaller number of larger deposits. It is true that up to the present the output has been small but this is due to financial and other conditions affecting development and not to the lack of material or conditons of occurrence. Capital and demand for the material are the factors required to produce a great development of the industry.

In regard to the uniformity of the deposits, it may be said that they do vary widely in percentage of bitumen within small distances, and that small samples collected from the same quarry or from different quarries show widely different percentages of bitumen. In quarrying, transportation, and preparation for the street, however, the material is so mixed that a very uniform percentage of bitumen results. The sand remaining after the extraction of the bitument from the sand asphalts is just as uniform, as well or better graded and is much cleaner than the sand usually utilized in the manufacture of the sheet asphalts.

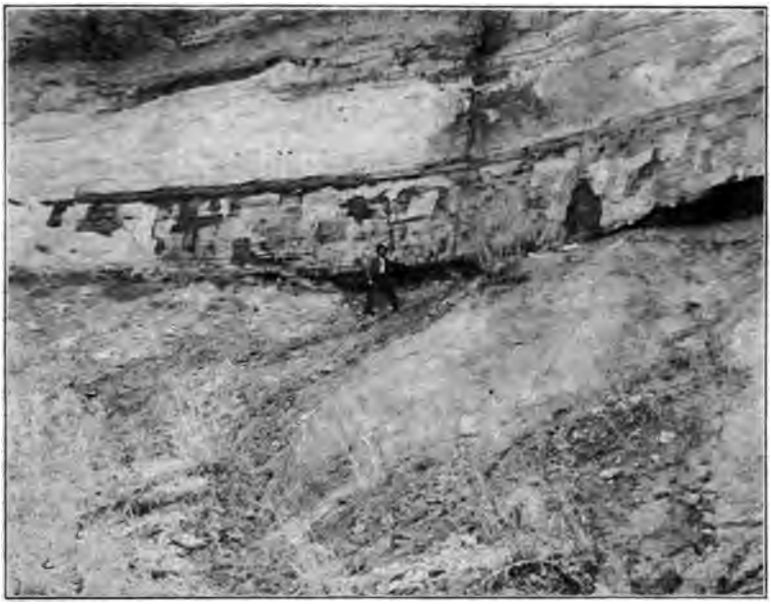

FIG. 7. OUTCROP OF ASPHALTIC LAYER IN TRINITY SAND NEAR RUSSETT.

The percentage of bitumen carried by the Oklahoma rock asphalt is not usually as great as that of the finished sheet asphalt pavement. However, the physical characteristics of the rock asphalts and the artificial mixture used for sheet asphalt are so different that it seems that comparisons should be made, not with the artificial mixtures, but with other rock asphalts which are known to have given good service in pavements.

The bitumen in the Seyssel (French) rock varies from 6 to 8 per cent, the Val de Travers (Swiss) rock will average about 10 per cent and the Mons about 9 per cent. The Sicilian asphalts run as high as 12 per cent bitumen. They are not used alone but are diluted with the less bituminous rock of Seyssel, Val de Travers or Mons. The situation in Oklahoma, then, is similar to that in Europe in that we have rock asphalts of varying bitumen content, some of which may be used alone while others are mixed to produce a pavement of the proper bitumen content.

As to the character of the bitumen it may be said that it is usually softer and more viscous than the Trinidad or Bermudez asphalts and shows a greater penetration than do those asphalts. However, it must be remembered that in the paving mixture the Trinidad and Bermudez asphalts are fluxed with residuum so that the penetration of the bitumen from the finished pavement is not very different from that from the hard pitch Oklahoma rock asphalt.

In any event, the uniformity of composition and physical character of the finished pavement is of vastly more importance than that of any single constitutent and in this respect the rock asphalts compare more than favorably with the artificial sheet asphalts. The sheet asphalt pavement samples in the following table were taken from one street and its crossings in the distance of four blocks while the rock asphalt samples were taken from pavements in four different cities and represent material from several quarries:

[1]Analyses of Sheet Asphalt Pavement Samples.

		Total Bitumen.	Asphaltene.	Petrolene.
I.	Muskogee	13.5	9.9	90.1
II.	Muskogee	11.0	38.2	61.8
III.	Muskogee	11.5	17.8	82.2
IV.	Muskogee	10.5	24.6	75.4
V.	Muskogee	12.0	29.8	70.2
VI.	Muskogee	11.0	21.9	78.1
VII.	Muskogee	9.1	32.9	67.1
VIII.	Muskogee	11.5	24.8	75.2
IX.	Muskogee	10.2	21.6	78.4
X.	Muskogee	9.7	28.5	71.5

[1]Analyses of Rock Asphalt Pavement Samples.

		Total Bitumen.	Asphaltene.	Petrolene.
I.	Ardmore	8.53	22.40	77.60
II.	Ardmore	7.85	21.19	78.81
III.	Ardmore	8.05	21.90	78.10
IV.	Ada	9.97	22.45	77.55
V.	Sulphur	10.10	27.35	72.65
VI.	Sulphur	9.80	29.39	70.61
VII.	Oklahoma City	9.95	25.21	74.79

[1] Analyses by H. I. Jones.

The results show that the rock asphalt pavement has a lower ut far more uniform bitumen content, and that while the average mposition of the bitumen is about the same, the composition of e bitumen from the rock asphalt is far more uniform.

The relative penetration of the finished pavements is shown by veral facts. In any of the sheet asphalt pavements of Oklahoma ity or Muskogee a knife blade can be easily thrust through the rface coat on a hot day and the sheets are marked by horses' oofs, wheels of vehicles or even by the heels of pedestrians. Some the samples from Muskogee were pulled from the street with the ngers. On days of as equally high temperature the rock asphalt reets of Ardmore and Sulphur cannot be penetrated by a knife. t Ardmore a loaded freight car was pushed from the end of a stub ack across the side walk, asphalt pavement, second side walk and n to the earth on the opposite side of the street. The car in passg off of the ends of the rails bent them into the ground. Both oncrete sidewalks were crushed, but the only damage to the ashalt pavement was a slight marking by the flanges of the wheels. n Lawton heavy circus parades have passed over the streets in arm weather and in one instance a heavy steam ditching machine assed over the whole length of a recently completed street with no ign of damage to the pavement. The rock asphalt pavements in he cities mentioned do not become unduly hard in the winter and o not crack or grind up.

It appears, then, that although the percentage of bitumen in the klahoma rock asphalt pavements is less than that in the sheet sphalt pavements, it is as great as that of the rock asphalt paveents of Europe which have given satisfaction for years. The bitmen is as asphaltic in character as that of the sheet asphalt and hile the bitumen of the rock asphalt has a higher penetration than e Trinidad asphalt, the finished rock asphalt streets are much ore impenetrable than the sheet asphalt streets.

The manner of laying the pavement is very simple. The conrete foundation is generally used, and is laid in the same manner s for a sheet asphalt street. The asphalt is delivered to the plant pieces easily handled by one man. These pieces are pulverized a hammer crusher, screened through a 3/8 inch screen and fed nto a drum which is heated to the required temperature (about 25° F.). Paddles force the asphalt through the drum and at the ame time mix it thoroughly. From the drum the heated asphalt s dropped into wagons and hauled onto the concrete foundation, pread by raking, and rolled with a light roller, 2½ tons, afterwards vith a heavier roller. The wearing coat is two inches thick after olling. While cooling the pavement is swept with Portland cement r limestone dust and after cooling is open to traffic. Where more han one asphalt is used, pieces from piles of the different varieties re fed into the crusher in rotation. Some of the most successful avements have been made of a mixture of equal portions of a bituminous sandstone containing a hard pitch, and a bituminous sandstone containing a soft pitch and a bituminous limestone. These are from the deposits of the Ardmore, Buckhorn, and Brunswick districts. The Ada asphalt has been used alone in Ada, Lawton, and other places. It is a calcareous sand asphalt. In Lawton, instead of using the concrete base, the earth base was well compacted and then a foundation was made of the poorer portion (stripping) of the asphalt from the Ada quarry, containing 4 to 7 per cent bitumen and broken to pass a 2½ inch ring, with sufficient fine material to fill the voids. This was laid cold and rolled in two courses of 2 inches each, making a base four inches in thickness. This pavement has been in use 4 years and the city engineer reports the base to be very satisfactory, only one small crack appearing in the surface coat of three miles of pavement.

The danger of over heating in the rock asphalts is very slight. Since each rock particle is already coated with bitumen only a moderately high temperature is required to soften it for mixing and for rolling. The rock asphalt is heated to about 225° F. in the heater while Richardson recommends that the Trinidad and Bermudez surface mixtures reach the street at temperatures of from 280° to 340° F. It is manifestly necessary to heat the artificial mixtures to a higher temperature to insure perfect mixing than it is the natural mixtures where each particle is already coated with bitumen.

The price of sheet asphalt pavement in Oklahoma is about $2.[illegible] to $2.50 per square yard. The Oklahoma rock asphalt pavement can be laid anywhere in the state for less than $2.00 per square yard. The price in Kansas City has never exceeded $2.15. The fact that the entire surface mixture must be transported from the mines or quarries in the case of the rock asphalt, while for the artificial pavements only the bitumen need be imported from a distance and the mineral aggregate can be obtained from near at hand, handicaps the rock in competition with the sheet asphalt at a great distance from the mines. At present the rock can compete with the sheet pavements within a radius of 500 miles or so of the mines. When the mines and quarries are developed on a larger scale this radius will be increased on account of the less cost per ton of production of the rock. Judging from the qualities of the pavement already laid, the area in which the rock can successfully compete with the sheet asphalt will be greatly increased by the recognition of the greater value of the natural rock pavement.

Up to the present the Oklahoma rock asphalt has been used for paving in several cities in Oklahoma and Texas and in a few other cities. A partial list of the places in which the material has been used includes Kansas City, Kansas; Kansas City, and Sedalia, Missouri; Fort Worth, Paris, and Sherman, Texas; Ardmore, Lawton, Hugo, Oklahoma City, Muskogee, Tulsa, Holdenville, Norman, and Sulphur, Oklahoma.

In the following paragraphs a few statements from city engineers and others acquainted with the pavements of the Oklahoma asphalts are given.

S. F. Peckham, in his book, "Solid Bitumens," (page 287) says: "In Ardmore, a number of streets have been laid in a manner more nearly approaching the method pursued in Europe. The materials used were taken from quarries a few miles south of Ardmore, and were thoroughly mixed after being softened by heat. The material was spread on a concrete foundation without a binder and rolled until cold. When I inspected this street on one of hottest days in August, it was as solid as a rock. I know of no such streets in an Atlantic or Pacific coast city. They are the product of the intelligent application of sound principles of technology to the manipulation of the best materials for the construction of solid bituminous streets yet found on the American Continents."

Dr. C. N. Gould, former director of this survey, in an address makes the following statement: "Within the last year I have been very much interested in the subject of good pavements and have taken occasion to examine the asphalt streets in a number of northern and eastern cities, Baltimore, Washington, Pittsburg, Chicago, Kansas City, St. Louis and places nearer home, and I think I am safe in making the statement that Ardmore has at the present time the best paved streets in America."

Equally as good streets have been laid in Sulphur, Oklahoma. Some cracks have appeared running entirely across the streets in these pavements, but they seem to be due to the settling of the foundation as the same cracks continue through the cement sidewalks. The asphalt surface along these cracks does not disintegrate but on the contrary seems to be "healing over."

The city engineer of Kansas City, Kansas, in a statement of May 25, 1909, says: "We have some of this pavement that has been down over fifteen years and with the exception of a few places where water has not been properly drawn off and allowed to stand, it has stood heavy traffic and is still in a good state of preservation.

"We have fifteen miles of other asphalt which has had to be repaired a great deal, while this pavement, except for plumbers' cuts, gas company's and water company's cuts, has had no repair at all.

"Some of the streets of Kansas City, Mo., have been paved with this material and they are in better condition than some sheet asphalt streets that have been paved later, after being down fifteen years.

"Last season there were laid in this city 22,000 square yards of rock asphalt and this year there is being laid and petitioned for about twice as much more, which ought to show that it is giving satisfaction here."

Lawton, Oklahoma, has three miles of this pavement with both base and surface of the Ada asphalt, laid in 1909 and 1910. Four miles are under construction or contracted for. The city engineer reports as follows (Jan. 6, 1913):

"This pavement has stood all the demands of traffic and shows no wear except in places along the gutters where horses have stamped repeatedly and a few places where faulty material crept in.

"While our traffic is not what would be called heavy in a city, quite large frame buildings have been moved over it on wheels not over twelve inches wide and large circus parades have been over it with no apparent settlement; on one occasion a large steam ditching machine was run the whole length of one street shortly after completion with no permanent sign of damage to the pavement.

"With this base there is no tendency of the wearing surface to crack and I know of but one small crack in the three miles of pavement.

"Our present contract is being constructed the same way except that the greater part of the material for base is obtained from a mine within two miles of this city."

Sedalia, Missouri, has used no asphalt for paving for the last fourteen years but of the old asphalt pavement, the city engineer reports the natural rock as being in a great deal the better condition.

These are only a few of the statements at hand but they are sufficient to show that the pavements constructed of the Oklahoma asphalts are successful and that these asphalts are, at least, worthy of consideration as a paving material.

OKLAHOMA GEOLOGICAL SURVEY.

Governor R. L. Williams, State Superintendent R. H. Wilson,
President Stratton D. Brooks, Commission.
C. W. Shannon, Director.

CIRCULAR NO. 6.

ANIMAL AND PLANT LIFE IN OKLAHOMA

BY

OKLAHOMA GEOLOGICAL SURVEY

NORMAN.

October, 1917.

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CONTENTS.

Page

- Introduction 5
- Chapter 1.—Animal life in Oklahoma 7
  - Introduction 7
  - Hoofed animals 8
    - Buffaloes 8
    - Antelope 8
    - Deer 8
  - Flesh-eating animals 9
    - Rocky Mountain lions 9
    - Bears 9
    - Loafer wolf 9
    - Coyotes 10
    - Badgers and skunks 10
    - Other flesh-eating animals 11
  - Gnawing animals 11
    - Beavers 11
    - Prairie dogs 11
    - Gophers 12
    - Rabbits 13
    - Small rodents 13
    - Moles 14
    - Bats 14
  - Birds 15
    - General statement 15
    - Wild turkeys 15
    - Prairie chickens 15
    - Quail 16
    - Hawks and owls 16
    - Woodpeckers 17
    - Eagles and vultures 17
    - Water and shore birds 17
    - Crows 18
    - English sparrows 18
    - Song birds 18
  - Fish and mussels 20
    - Fishes 20
    - Mussels 20

Page
Reptiles 21
    Snakes 21
    Turtles 22
    Lizards 22
Insects 22
Summary 23
Classified list of wild animals in Oklahoma 24
Chapter II.—Plant life in Oklahoma 37
Introduction 37
Physiography and geology 37
    Salt Plains 38
    Gypsum Hills 39
    Sand Hills region 40
    Black Mesa region 41
Soils 41
Precipitation 42
Life zones 42
Relation of physical conditions to the flora 42
Relation of our flora to that of adjacent regions 43
Distributing agencies 44
Plant families in Oklahoma 46
Trees and shrubs 55
A list of trees and shrubs in Oklahoma 58

ANIMAL AND PLANT LIFE IN OKLAHOMA.

INTRODUCTION.

The urgent needs of the public schools in Oklahoma for available information concerning the animal and plant life, and similar demands of the general public for the same information, lead to the preparation of the present publication. In connection with the regular duties of the field men of the Oklahoma Geological Survey, a large amount of available information is gained concerning the natural resources of the State, which is of value from an educational and scientific view, as well as from an economic standpoint. The cooperation of the members of the Oklahoma Academy of Science has made such a publication possible. These chapters on the animal and plant life of Oklahoma were published as Chapters VIII and IX in Bulletin No. 27, Geography of Oklahoma, recently issued by the Oklahoma Geological Survey.

The chapter on animal life in Oklahoma was written by Mr. Howard Cross, of the Department of Zoology, Oklahoma University. Dr. H. H. Lane, Head of the Department of Zoology, offerede much valuable assistance in the preparation of this chapter, and checked the scientific and common names used in the list of wild animals. Mr. Frank Rush, Forester in charge of the United States Forest and Game Preserve, in the Wichita Mountains, also furnished much information of value concerning the animal life of the State. Credit is due to many others who contributed to the data used in the chapter.

The chapter on plant life in Oklahoma was compiled from the manuscripts of unpublished reports on the plant life of Oklahoma, by Mr. G. W. Stevens, formerly Head of the Department of Biology of Northwestern State Normal, Alva, and Mr. C. W. Shannon, Director of the Oklahoma Geological Survey. These manuscripts mentioned include a report on the flowering plants of Oklahoma, by Mr. Stevens, and a report on the trees and shrubs of Oklahoma by Mr. Shannon.

C. W. SHANNON, Director.

OKLAHOMA GEOLOGICAL SURVEY,
Norman, October 1, 1917.

A. HEAD OF BEAVER DAM ON WOLF CREEK, HUNTER'S RANCH, NEAR FARGO, ELLIS COUNTY.

B. SHOWING TREE CUT BY BEAVER AT ABOVE LOCALITY.

CHAPTER I.

ANIMAL LIFE IN OKLAHOMA.*

INTRODUCTION.

Oklahoma at one time had a wealth of animal life that seemed most impossible of exhaustion. Not only were birds and animals found re in unbelievable numbers, but the range in species was perhaps eater than in any other area of like size in the western part of the nited States. Many of the animals characteristic of the mountainous gions of the west extended to the foot hills of the Rockies and often curred in the western part of this State. Animals commonly found in e rough and timbered regions of the east came as far westward as e Ozark Mountains and remained in Oklahoma in considerable numbers. hile the roving herds of the vast open plains of the northwest found mple pasturage and shelter here during the winter months and some- mes grazed beyond the southern boundaries of the State. To this mense throng must be added the myriads of semi-migratory birds and imals of the south that were found during a part or all of the year with- the present limits of Oklahoma. The location of the State makes it sort of meeting place, or focal point, for a variety and abundance of imal life that would not be possible under any other conditions.

The multiplicity of habitats existing in Oklahoma also makes possible range in animal life that few states enjoy. The arid regions of the stern part of Oklahoma have, or had, a large representation of all the ried fauna characteristic of the great semi-desert region to the north d west, while the mountains within the State offer range and protec- on to a vast assemblage of animals that our rapidly advancing civiliza- on has not yet been able to destroy. Our broad streams and lakes have rnished shelter and food to water and shore animals that may still be und in abundance in regions not frequented by man, and the timbered gions of the south and east support a wealth of woodland forms that uld not exist in localities where forests do not abound.

The changes incident to the settlement of a new country by man avoidably cause the destruction of the feeding grounds and shelter of e wild animals, and as the improvement is pushed farther and farther into the wild retreats, the native animals become less and less abundant and finally must perish altogether unless given some measure of protection. The advent of man into Oklahoma has, of course, very materially lessened many kinds of wild life, but fortunately only a few species have been lost entirely, and the location of a National Game Preserve within the State, and the provision recently made for the establishing of State game preserve, give assurance that no species now living in Oklahoma will ever be reduced to the point of extinction. We shall always have at least a remnant or sample of the faunal wealth that once abounded in this State.

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*This chapter was prepared by Howard Cross, Department of Zoology, lahoma University.

HOOFED ANIMALS.

BUFFALOES.

The buffalo is the largest wild animal that has lived in Oklahoma in modern times. Within the memory of men now living, this noble animal roamed over the prairies in countless numbers, and at times whole valleys were covered with vast, unbroken herds. Great as this throng was, it went so quickly after the coming of the railroads that men could not believe it gone. In the fall of 1884 the hunters came to kill the buffaloes for their hides, which they sold for one dollar and a half apiece. but none could be found. "They are gone north," the gunners said, but they had not gone north; they had all but gone to utter extinction! At one time there were only twelve buffaloes in the State, but now there are eighty-four head in the Wichita National Game Preserve in Comanche County, and a small herd at the 101 Ranch in Kay County. The splendor and vigor of this remnant, however, are gone and they trail after a wagon to be fed, as broken and fearless as domesticated cattle.

ANTELOPE.

Antelope, while never so abundant as the buffalo, were very numerous in this State before the coming of the cowboy and his civilization. They often grazed in herds of several hundred and were well adapted to live in rough country. They remained somewhat longer than the buffalo, for the last antelope in Oklahoma, which lived in the southern part of Ellis County, were not killed until 1910. Since that time not a free antelope has lived within the State, and only a single specimen is held in captivity. This is a male and is on the Government Preserve in the Wichita Mountains.

DEER.

Deer were one time very abundant in the timbered sections of this State, and on account of their wonderful speed and cunning they have evaded the destructive forces of man and may yet be found running wild. Their range is now restricted to the mountainous regions, and it is doubtful if there are more than one hundred and fifty wild deer in the State today. Most of these are in the Kiamichi Mountains, where the persistent and criminal efforts of hunters to kill them will no doubt soon be successful in securing the last specimen.

FLESH-EATING ANIMALS.

ROCKY MOUNTAIN LIONS.

The larger flesh-eating animals were never numerous here. but there were enough during the time of early settlement to cause considerable damage to stock and to instill a constant fear in the lonely traveler. The Rocky Mountain lion was known in this State as late as 1900, and it is possible that a few stragglers are yet in some of the mountain districts, but they are difficult to find and are not often seen. One came as far east as Grant County in 1895. This animal followed Pond Creek with its sheltering timber, and left the protection of the woods at Jefferson long enough to spring into a man's yard and devour a pig. A few nights after the occurrence just narrated, a farmer living west of Jefferson was annoyed by the low, frightened growl of the family dog. When the door was opened the dog shot out into the darkness and a sharp yelp was heard. The next morning the hind leg of this courageous but imprudent dog was found about one hundred yards from the house. This is the last record of the misdeeds of this Rocky Mountain lion before it was finally hunted down and killed.

BEARS.

Bears are in many ways the most interesting animals of this State. They have never been abundant and have always been restricted in range to the more inaccessible timbered regions of the mountains. These animals have inflicted very little damage on the stock raising interests of the State, and have never been known to attack man unless driven into a corner, or wounded. Bears, as is the custom of all such animals. go into their dens early in December and sleep through the cold winter months, and emerge with the coming of warm weather in the spring. They spend much time at play when in the company of other bears, and if taken when young make very amiable pets. Their thick heavy coats protect them from injury even in very rough frolics, and they often acquire habits of play that make it imprudent to present the bare hand to even the most gentle of bruin pets. They feed on succulent roots, insect larvae, honey, fish, frogs, and almost any other kind of flesh they can secure. At one time it was thought that two kinds of bears lived in Oklahoma, but the small Black bear is probably the only specie which is found here. In the early spring when it emerges from the long winter's sleep, its usual coat of black has become very long and has a dusky brown color that is perhaps responsible for mistaking it for the so-called Brown bear.

LOAFER WOLF.

Wholesale destruction marks the path of the large Gray or Loafer wolf throughout its range. This animal was never abundant enough to extend over any considerable portion of the State, but in bands of from four to eight they were able to kill deer and buffalo, and with the coming of cattle and sheep they were responsible for a destruction that aroused a widespread demand for their speedy extermination. The "six-shooter," so characteristic of the western cowboy, was originally carried for the purpose of killing this wolf, but the practice soon spread far beyond the limits of the Loafer range and probably will be kept alive forever in the "movies." The ranch owner furnished the guns and ammunition to the cowboys and they were given the skin as a special reward if they were fortunate enough to kill one of these destructive beasts. The Loafer wolf generally frequents the rough country and forages over definite ranges which he covers in cycles every seven days. Settlers have taken advantage of this unusual habit and have proceeded by systematic poisoning to protect their herds from these marauders. The Loafer is now practically extinct in this State, and its passing will be a signal for unbounded rejoicing by cattle men everywhere who have herds within its range.

COYOTES.

The coyote is one of those unfortunate members of our animal society whose position has not been understood and whose services have never met with the appreciation which they deserve. These animals are distributed throughout the State but do not occur in large numbers in any particular locality. The coyote has long been known as a chicken thief, and does occasionally frequent poultry yards that have been carelessly left open at night, but it renders a service to the farmer in the destruction of large numbers of mice, rats, gophers, and rabbits that pays many times over for its one unfortunate indulgence. The coyote may not be an altogether desirable resident of a crowded agricultural district, but it is capable of much good and by no means deserves the unenviable reputation which it has.

BADGERS AND SKUNKS.

With the possible exception of hawks and coyotes no living animals have been more unjustly persecuted than the badger and the common skunk. Both have a few bad habits, but if a ledger of all their services were kept it would show such a balance in their favor as would put to shame the army of thoughtless men and boys who annually pursue to certain and unmerciful death these valuable allies of the farmer.

Badgers were at one time fairly numerous in this State, but persistent and systematic killing by everybody has so reduced them that only a few remain. They can live in arid regions where the annual rainfall is so slight that it would seem impossible for any animal to survive. They live in burrows, and have flat, compact bodies with powerful fore feet and claws which enable them to dig with a rapidity that few animals attain. They are thus equipped to dig out and destroy myriads of ground squirrels, gophers, and prairie dogs, which, on account of their habits of life, are practically immune from the attacks of all other predatory animals.

The skunk, of which several kinds occur in Oklahoma, is scattered more generally throughout the State and perhaps has a few more bad habits than the badger, but the record in its favor is scarcely less astounding. Skunks are preeminently animals of the field and wood, and their occasional appearance in the farm yard is accidental. They work, for the most part, at night, and the number of noxious insects, mice, and rats which they annually unearth and devour is almost beyond belief. The furs of these animals are becoming very valuable and a splendid income awaits the boy who has the ingenuity and courage to collect a number of skunks and organize the first fur-growing industry in Oklahoma.

OTHER FLESH-EATING ANIMALS.

Other flesh-eating animals existing in Oklahoma are the bobcat, raccoon, o'possum, weasel, and mink. These animals exist abundantly in some portions of the State, while in others they have already been exterminated. The weasel and bobcat were once found on the open plains wherever prairie dogs lived, but they have long since been driven to the protection of the timber, and even here they are only rarely seen.

GNAWING ANIMALS.

BEAVERS.

The beaver is the largest gnawing animal in Oklahoma, and easily leads the mammals of the world in mechanical and engineering skill. Beavers were at one time common in many of our smaller streams, and the line of their retreat is marked by dams and houses which they were forced to abandon hurriedly, in their efforts to keep away from the habitations of man. Wherever the banks were too low for the beavers to burrow into, they constructed dams across the channels and often raised the water as much as four or five feet, forming large artificial ponds with a depth sufficient to protect the entrance to their houses, and to provide for storing a food supply large enough to carry the beaver colony through the period when the ponds were frozen over and they were cut off from the usual food beyond the limits of the water's edge. The trees generally selected by the beaver for food include the birch, cottonwood, hickory, ash, and willow. To secure the tender limbs and younger shoots they often "cut" down trees as large as a foot in diameter. If only the smaller limbs were used they were cut off and dragged to the pond, but if the trunk was needed for strengthening the dam, a channel was dug from the pond to the tree and the timber was floated into position, as is the custom of lumbermen in all parts of the world. There is only one colony of these interesting animals now within the State. This is located on a small stream in Ellis County. It is hoped that the men who own the adjoining land will see that measures are taken to prevent this last picturesque beaver "town" from being depleted of its industrious population.

PRAIRIE DOGS.

Prairie dogs, which exist so abundantly in many parts of Oklahoma, are social creatures and live together in communities called towns. A colony may cover only a part of an acre, or it may be miles in extent. The population ranges accordingly from a few individuals to as many as 100,000 in the larger towns. They burrow into the ground to a depth of about 12 feet and they extend the den in a horizontal direction for a distance of from 10 to 15 feet. Any number of lateral channels may extend from this main run. Usually only a single pair occupies a burrow, except in the spring when the four young arrive. The ground for a considerable distance around the mouth of the burrow is stripped free of vegetation, and in thickly settled communities these barren spaces connect, so that large areas of grazing land are sometimes entirely cleared of grass by the presence of these animals. Prairie dogs are not really dogs in any sense of the word, but are large squirrels, and as they subsist entirely on roots, grasses, grain, and vegetables there is no reason, except perhaps the name, why they should not be as palatable as timber squirrels or rabbits. They are preyed upon by wolves, coyotes, bobcats, weasels, and the larger hawks, but since man has driven away or destroyed these natural checks the prairie dogs have increased at a corresponding rate and artificial control must be put into effect. The United States Biological Survey has perfected an effective and inexpensive method for poisoning the prairie dog, and its general use throughout the State is bringing back into cultivation large areas that were formerly occupied by these animals.

GOPHERS.

The common pocket gopher is by all odds the most destructive animal in Oklahoma. We have at least two species in this State; a small one found widely distributed but never numerous; and the large red pocket gopher that is causing more waste at the present time than any other living creature within the State. The gopher is the builder of the countless mounds of dark earth that we see thrown up over prairies and fields wherever we go. Some alfalfa patches have been more than one-tenth covered by these tell-tale hills. The gopher has a compact, muscular body, and with its powerful front feet and claws is able to burrow rapidly through the soft earth. The burrow or "run" usually extends about a foot beneath the surface. and at short intervals vertical tunnels extend upward to the top of the ground and through these the excavated soil is carried out and thrown up in small heaps. A single gopher occupies a burrow and often extends it several hundred feet in a season. The animals live, for the most part, on the roots and tubers which they find in their journeys through the ground. The gopher sometimes emerges from its burrow and fills its pockets with tender leaves and grain, which it always carries into the burrow before eating. Stock are often injured by stepping into gopher burrows, and many a cowboy's life has been lost in a fall caused by his mount plunging a leg into one of these burrows. A few kernels of poisoned grain placed in each burrow will rid a farm of these destructive pests within a reasonably short time. Little, however, will be accomplished unless whole communities cooperate, for a single farm cleared would soon be errun from adjoining territory. The animals are still very numerous certain parts of the State, and unless some concerted action is taken check them in the localities where they abound, they will presently doubling the damage they are now inflicting. The gopher rarely seen above the ground and as a result has few natural enemies except e badger and the bull-snake, both of which have been so reduced by an that now the gopher is practically free to multiply unmolested. he responsibility rests entirely with the land owner; he must act now pay a constantly increasing penalty.

RABBITS.

The most frequently seen and best known mammals of Oklahoma e rabbits. They refuse to be exterminated and are found in every cality in the State. We have two kinds of rabbits—the large, long-gged variety with athletic form, known as the jack rabbit, and the uch smaller rabbit, known as the cottontail. The jack rabbit frequents e open plains. It does not burrow, but depends on its keen vision d powerful legs to keep it out of danger. The nest is made in a all, obscure depression in the ground and lined with soft wool taken om the breast of the mother. The cottontail frequents the wooded d more protected areas. It has short legs, wholly unfit for prolonged ght, but easily makes up for this loss in swiftness and cunning. It rrows well under stones or projecting roots, where it is free from the ual annoyance of men and dogs. Then, too, its color so harmonizes th its surroundings that it is often obliged to seek flight to avoid ng trodden upon. Both jack rabbits and cottontails are wonderfully lific, often rearing as many as four litters during the summer. They d on grasses, grain, growing wheat, vegetables, fruit, and in winter. en pressed by hunger, they sometimes gnaw the tender bark from ng trees. A few wisps of green alfalfa hay scattered regularly ut the orchard in winter is the best protection against such attacks. e wholesale destruction of hawks, owls, wolves, and coyotes has noved the natural checks on rabbit production and occasionally they ome so numerous in certain localities as to inflict great damage on growing crops and trees. If properly cared for, their bodies can made an important contribution to the food supply of the State. e men who hunt have done much to hold the rabbits in check, but netimes this is not sufficient to keep them within the proper limits, d large hunts organized on a competitive basis often result in the ughter of thousands in a single day. These hunts sometimes embrace much as one-third of a county, and the men and boys taking part mber into the hundreds.

SMALL RODENTS.

In addition to the gnawing animals discussed above, Oklahoma s the muskrat and the usual army of small rodents that exist abundtly throughout the entire State. The red and gray squirrels are und wherever timber conditions make it possible for them to live, and in the southern part of the State there are two species of "flying" squirrels. The striped ground squirrel, smaller than its timber cousins, burrows into the ground in meadows and grain fields and is responsible for an annual damage of more than $100,000. Rats and mice exist in abundance throughout the State, and the destruction which they cause in fields and store-houses is common knowledge. But we can avoid much of this loss. If shelter such as heavy grass corners, weeded fence rows, mulching, and unraked hay, is burned or removed, and skunks, hawks, owls, weasels, and bull-snakes are not foolishly killed on account of superstition and hearsay, but are protected as friends, the army of these destructive rodents will soon be so lessened that the annual damage from this source will be reduced to very small proportions.

MOLES.

Moles have long been the unhappy victims of circumstantial evidence. They spend most of their active life in plowing through the soft earth in search of insects, and are guilty of only a few of the crimes with which they are so often charged and convicted. Their food consists almost entirely of insects, and if they are confined in a cage with nothing but vegetable food they soon starve. Moles are attracted to localities where burrowing insects are most numerous, and their presence in a yard or garden indicates that unseen insect pests are at work beneath the ground. The farmer observes a fresh mole run extending the length of a row of planted seeds, and if the seeds fail to come up the damage is charged to the mole and every effort is made to see that summary justice is executed. In reality, the mole was attracted by the grubs that were feeding on the sprouting roots, and was not even remotely interested in the seed. Then to further cloud the real issue, field mice take advantage of the protecting shelter of the mole tunnel and follow up, destroying all seeds and roots that have been exposed by the mole. To these trespassers is directly chargeable most of the destruction usually attributed to the mole. However, the mole is not entirely blameless. Its runs, when extended into lawns, render them unsightly, and many small roots are displaced and plants killed by the tunneling of this industrious animal. They should of course be kept out of yards and gardens, and this can be done by persistently trampling down their runs. The moles will thus be saved for carrying on the work of destroying underground insects in the fields, for which nature has so admirably fashioned them.

BATS.

Bats perform much the same service in the air that moles do beneath the ground. Their diet is made up largely of insects, and they contribute in no small way to holding these pests in check. It is true that we do not often see them at work, for they hang head downward under some protecting object during the day, but at dusk they come from their hiding and with a wierd, broken flight pursue and capture almost every kind of insect that moves about after night. Bats have little to commend them in the way of beauty or interest, but their persistent destruction of insects represents a saving to the State that should never be overlooked.

BIRDS.

GENERAL STATEMENT.

Oklahoma has a wealth of bird life of which she may be justly proud. Native birds occur here in abundance throughout the year, our rivers and lakes invite the migratory water fowls that annually pass this way, and the wooded streams and timbered hills offer shelter to countless birds that come here every year to nest and rear their young. The bird population is, of course, not as large as it formerly was, but while many valuable and beautiful birds have been reduced and driven to the verge of extinction, only a few species have as yet been entirely lost, and the general awakening of interest in bird life throughout the State marks the beginning of a new and brighter day for our feathered friends. We may confidently expect them in greater numbers as the forces for their protection are taken over by willing hands and carried into new and broader fields.

WILD TURKEYS.

Wild turkeys, like many of the larger native animals, formed no small part of the food supply of the pioneers, and in this way they have rendered a service of importance in the development of the State. These birds were at one time very numerous, but were so easily approached and shot that they were annually slaughtered in great numbers. It was not uncommon in the early days to see as many as five hundred of these splendid birds in a single bunch, and one hunter reports having seen a solid, unbroken acre of turkeys. Their habit of roosting in trees probably contributed in a large measure to their destruction. Hunters would locate a bunch, and after the turkeys had flown into the trees for the night, would walk quietly under them, where their large bodies outlined against the sky made an easy mark for a rifle. A man from Jefferson, with two companions, thus killed eighteen turkeys in one evening. A few wild turkeys are yet free in the mountainous regions of the State, but unless they receive legal protection it will be only a short time, at the present rate of destruction, until they are vanquished. Then we will have only the flock in the Wichita Preserve, which is as tame and fearless as poultry.

PRAIRIE CHICKENS.

We have left only a pitiful remnant of prairie chickens. They have been driven from the plains and rolling sand hills where they normally thrive, into wild retreats where they can secure some measure of protection from the constant illegal war that is being waged against them. A few flocks may yet be found in the Panhandle district, and a small number have in some way kept alive in Ellis County, but they represent only a small portion of what formerly existed here. Flocks of a thousand birds were sometimes reported, and a hunter with two companions once killed a wagon load of chickens on one hunt. The law provides no open season on these birds, and they may be brought back to an abundance where they can again be hunted, but it will take a long time and a more strict enforcement of the law than is now maintained.

QUAIL.

If the United States ever sees fit to erect a Hall of Fame for its birds, the quail will occupy one of the chief places, for it is by all odds the most valuable bird in North America. This is due not for its meat alone, although this is a delicacy that is seldom, if ever, surpassed, but for the constant, unselfish service which this bird renders to the farmer in its never-ending war against the ravages of insects and weeds. The quail is an ally of the farmer, staying at his post throughout the entire year and working on an average ten hours a day. In the summer it runs down and consumes as many as one hundred and fifty different kinds of insects, and in the winter it gathers and eats almost as many varieties of noxious weed seeds. This bird has diminished in number in Oklahoma, not at the hands of hunters alone, though they have contributed in a large measure, but also because farmers have thoughtlessly burned over its nesting and feeding grounds, and have made no provision for it in the new order on the farm. Every effort should be made to bring the quail back to its former abundance, and to anyone within the State who will provide suitable nesting places the State Game Warden will furnish free of charge a stock of these birds. There are a few counties where the quail is yet numerous enough to justify hunting it, but such places are exceedingly rare. Wherever this bird is diminishing, it is not only an economic blunder but a crime to decrease the number.

HAWKS AND OWLS.

Besides the quail we have a number of other birds that annually make a large contribution to the wealth of the State through the service they render to the farm and forest. Hawks and owls stand at the head of this list, but unfortunately the first of these two does occasionally take a chicken, and this causes it to be branded as a thief and an outlaw. No thought is given the excellent service which it renders through the months when it neither attacks nor cares to attack poultry. The average adult hawk consumes each day at least six mice or their equivalent in other rodents or harmful insects. Since we have learned by experiment that a single mouse causes an annual damage of at least two cents, it is a simple process to compute that each adult hawk is worth more than forty dollars a year to the farmers of the State. There are two exceptions—Cooper's hawk, and the sharp-shinned hawk. These species are thoroughly bad and deserve to be shot wherever found, but they look so much like beneficial hawks that it is unwise to hunt them in the field. A better plan is to have a gun at hand and be prepared to execute summary vengeance on any marauder that dares approach the chicken yard. Owls possess all the good habits of hawks, with none of the bad. They also have the additional advantage of working at night when the rodents are running about, so that it is difficult to compute the economic importance of the silent army of owls with representatives in every community within the State.

WOODPECKERS.

We have not less than ten different kinds of woodpeckers, and each of them represents a distinct value to the orchard and timber interests. They carry on an interminable search for the deadly grubs and other insects that burrow into and endanger the life of trees. Wherever a forest insect pest develops in any section it is sure to attract an army of hammering woodpeckers, and the birds are soon the victors. They also have played a part in spreading the forests. These birds are, in fact, real foresters, in that they are persistent planters of trees and do not give up their watchful care over them as long as they harbor a single insect pest. Yes, they do drill holes in telephone poles and riddle church steeples, but school boys carve their names on beautiful desks. Both are seeking to be perpetuated; there is no more reason for destroying one than the other.

EAGLES AND VULTURES.

People have never ceased to wonder at the matchless flight of eagles and vultures. They soar far into the upper atmosphere and float on motionless wings so smoothly that they appear as mere spots against the sky. It is said that these birds are never caught in the fury of the storms but fly above the clouds and descend only after the wind has spent itself. Both the golden and bald eagle frequent this State and have been known to nest in the mountainous regions of the south and east, but they occur in very small numbers and are only occasionally seen. The turkey and black vultures are found more abundantly and are commonly seen circling far above the earth in their constant search for carrion. They have keen powers of vision, and the characteristic "drop" of a vulture to a carcass will soon bring others from miles around.

WATER AND SHORE BIRDS.

Our State is situated within the migratory path of a very large percentage of all the water and shore birds that annually go north for the breeding and nesting season. Floating clouds of gulls are seen over the State during the spring and summer months, but on account of their powerful wings they do not often come to rest upon the ground. Solitary pelicans occasionally fly over, but they usually come in flocks. As many as one hundred and fifty of these feathered fishermen have spent the night on the Canadian River a few miles west of Norman. Ducks come and go throughout the entire year. On the protected lakes and ponds they become very tame and are often seen in great numbers. It is probable that more ducks occur in Comanche County than in any like area within the State. All told, at least thirty kinds of ducks frequent Oklahoma every year. Wild geese were once much more abundant than they are now, and while they do yet fly over the State in numbers, they seldom come down except in most inaccessible retreats, and it is a "red letter day" for the hunter who succeeds in bagging one of these birds. The towering form of the sandhill crane is sometimes seen along the larger streams, but its noble cousin, the whooping crane, has ceased to visit us. The great blue heron was never abundant here and its numbers now are very limited. However, we occasionally see this stilt-legged bird, with many of its small relatives, wading about the shallow ponds in search of crayfish and frogs. Its long beak makes it a dreaded hunter of the small streams, but Oklahoma will be the poorer if this ungainly but interesting bird ever disappears altogether from our shores.

CROWS.

Crows are a bad lot. They have a record of misdeeds almost as inky black as the coats they wear. Before the planting of grain fields gave them an unlimited food supply they were never numerous, but now they occur in numbers so large as to inflict heavy damage on the farmer in many sections of the State. Their fondness for sprouting corn is responsible for much of the trouble which they cause, but this is not all. Crows destroy large numbers of bird nests in the spring, and do not hesitate to feed the squawking fledglings to their own young. They come down in clouds on cane and kaffir fields and strip the heads before they can be gathered. This rapidly increasing multitude of destroyers presents a problem which will sooner or later have to be met. The crow has few natural enemies and is far too wise to be poisoned by the usual methods. A bounty is placed on their heads in many states, and this will probably soon be done in Oklahoma.

ENGLISH SPARROWS.

It is impossible to say anything too unkind about the English sparrow. There are few places in the State where this bird does not occur, and it is multiplying five times as rapidly as any other bird in North America. This bird is everywhere displacing the native birds, and is an invariable source of inconvenience about watering places and buildings. The English sparrow is not beautiful, cannot sing, and lives almost entirely on the hospitality of the farm. No one should lightly condemn a bird, but this one unquestionably deserves to die. These sparrows are gregarious in habit and can easily be poisoned in large numbers, so that any farm or city can entirely rid itself of these pests in one winter if it will only learn the methods and apply them.

SONG BIRDS.

Oklahoma is rich in the number and variety of her song birds. The larger part of these are, of course, migratory, and so remain here only a part of the year, but they make the woods merry with their songs from early spring until the horde of destructive insects is killed riven to shelter by the approach of winter. These feathered songsters only contribute immeasurably to the joy of living, which would be ment enough for their eternal protection, but they wage a ceaseless against insect pests and weeds everywhere. They work at all s when insects are about and pursue their prey into all accessible s. The robin is abundant here through the summer months, and ontinually combing the yards and gardens in search of pests. It delight to watch this representative bird attempt to teach its half- n young to shift for themselves, but they apparenly will not learn after days of patient but vain effort the exasperated parent leaves of a wriggling worm on the ground in front of the ravenous young- , and flies away. The young birds proceed in an awkward fashion nish their meal, and with the awakening instincts are soon able to ide for themselves. During the winter months robins are so numer- in the southern part of the State that trees are often covered with roosting birds, and vicious men go into these colonies at night with tern and when the frightened birds become bewildered and fly into ight they are struck down by the hundreds and their mangled bodies ed up and carried away for food. This condition applies, also, in rge measure to the cardinals. In the extreme northern part of the e this bird is migratory, but is a permanent resident of the central southern part of Oklahoma, where it often gathers in great num- They feed very little on insect life, but subsist for the most part reed seeds and wild fruits. Wherever they are found in large col- s they are preyed upon by degenerate and criminal men, who go t after night armed with lanterns, clubs, and sacks. If public senti- t in such communities is not strong enough to prevent this savagery, liscontinuance should be guaranteed by the State, even at the cost permanent patrol.

The present number of song birds can constantly be increased if citizens will only exercise a little patience and tact. Birds are quick cognize their friends and anyone who is willing to make the effort can le the number of birds on his premises in a single year. Many s are organizing bird clubs and providing nesting sites and food the birds that have suffered most on account of the change in nature sioned by the coming of man. These communities will reap a reward creased bird life that will repay the effort a thousand times. Aggres- effort for a worthy cause will ennoble the character of a girl or boy; ill create in the community a moral tone that is at once fine and tiful. The first-hand study of wild life and its systematic care and ection offer possibilities to the public schools of the State that have yet even been sounded.

One could not enumerate. much less discuss. in this brief account, he song birds of Oklahoma. There are more than one hundred kinds, every one is doing an excellent service for man and deserves every ection we can throw around it. Our bird life, fortunately, has not decreased so much as it has in some other states, and we may always have a wealth of feathered songsters if only we will it now.

FISHES AND MUSSELS.

FISHES.

Fishing in Oklahoma can never be successfully commercialized, for there are few large, permanent bodies of water within the State, and the depth and character of the streams are not such as to make possible the constant production of fish in quantities. Our rivers and creeks, however, contain a large number of excellent food fishes that will always furnish an abundance of wholesome sport for those who have the time and patience to go after them. Seining is legal in all the larger streams, and while too many fish are caught in this way, it probably will never materially lessen the supply, for the rivers are annually restocked from the larger streams during periods of high water. Some large fish are occasionally caught in Oklahoma. The yellow Mississippi cat is taken in many places, and specimens weighing as much as 100 pounds are not unknown. The blue and channel cat fish abound in nearly all our streams, but they are not so large. One weighing more than 50 pounds is extremely uncommon. Eels are found in most of the streams of the State. They range in size up to three feet in length, but the larger ones are rare. Among the scale fishes the buffalo, drums, and bass are the largest and most valuable, while the smaller ones including the goggle-eye, white, and sun perch are the most numerous and most widely distributed. The hickory shad is abundant in all the streams, but it is so thoroughly useless, and has choked so many uninitiated folk with its countless bones, that it does not deserve to be mentioned in an account of the fish resources of the State. Sturgeons and gars occur in all the larger streams and some attain considerable size. While we now have a fair amount of fish, they cannot always withstand the outrages being committed against them. Streams not more than 10 feet in width have been seined to the last fish, and one man was known to dynamite his own stream at spawning time! If, however, fishing is conducted in a sportsmanlike fashion, excellent and profitable sport can be assured and put on a permanent basis.

MUSSELS.

Fresh water clams or mussels occur abundantly in the Verdigris River throughout a large part of its course, and there is no reason why anyone living along this stream could not increase the resources of his farm by a little study and care in the propagation of these animals. Their shells are worth from $8 to $60 a ton, and the occasional finding of a valuable pearl adds an element of excitement and possibilities of

erman has secured a pearl from that community which he had sold
$525. The mad excitement which this created did not fully spend
elf until the last mussel from that region had been hauled from the
ter and examined. The clam industry probably never can be de-
oped to large proportions in this State, but it can be made an addi-
nal source of revenue for those who have land located along suitable
eams.

REPTILES.

SNAKES.

A fear once deeply grounded in the human mind can not easily be
stroyed. This explains why we draw back with uncontrolled fright every
ne a tiny snake crosses our path. There are, of course, poisonous
akes, but we have only four of these in Oklahoma—the rattler, the
pperhead, the cotton-mouth moccasin, and the coral snake. All
r other snakes are no more poisonous than a rat or dog, and there is not
arly as much reason to fear them. The little spreading viper is
ally devoid of any poison glands, and its peculiar habit of spreading
head is only a ruse to fool people, a ruse which to this day works
ll. The monster bull snake is as harmless as a pelican and worth
hundred times as much. It spends all its active life in search of
phers, rats, and mice, and is one of the most effective forces in holding
ese destroyers in check. This snake is the only foe of the pocket
pher, except the weasel, that can enter its burrow and pursue the
upant to certain death. It is not uncommon to find that a gopher
ght in a trap has been half swallowed by one of these snakes, which
nd an impassable obstacle in the trap and gave up its victim. Two
ge bull snakes permitted to remain about a store-house will do more
keep down destructive rodents than five times as many cats. We
ve about 40 kinds of snakes in Oklahoma, but only the four named
ove are harmful. Poisonous snakes have distinctive characteristics
an can be recognized at a glance. They usually have a head that is
stinctly marked off from the body and does not taper gradually
to the trunk region, as is the case with all harmless snakes. In addi-
on, the rattlesnake, copperhead, and cotton-mouth moccasin have
avy depressions or pits between the eyes and the nostrils, and the tail
abruptly blunt. The rattler is a true sportsman. His bite is always
adly but he never strikes without first giving warning, and will eat
creature until its life is completely extinct. These snakes were at
e time numerous over the prairies but they are now nearly extinct
cept in the rougher, unsettled regions. No one, of course, regrets the
ssing of this most deadly animal, but it is a pitiful condition that
an insists on making an indiscriminate warfare on even the creeping
ings on the earth that do us no harm, and which must ever be sacri-
ed on account of a superstition and false fear that are centuries old.

TURTLES.

Besides the snakes, Oklahoma has a widely distributed reptile population that is both varied and interesting. The turtles and terrapins, of which we have more than 12 varieties, are cold-blooded creatures that lie dormant during the winter months, but are seen crawling or swimming everywhere in the summer. The soft-shelled turtle is especially abundant in many of the rivers, and the tortoises are familiar objects in the fields and gardens. The members of the turtle group in Oklahoma are for the most part rather small, but a few large ones are occasionally taken. Recently an alligator-snapping turtle weighing 110 pounds was taken from Blue River near Durant. When this specimen was discovered a member of the party ventured certain familiarities and extended the paddle end of an oar to within a few inches of its head. At once the massive jaws snapped away a portion of the oar and signaled a warning that was not to be disregarded. These larger reptiles are not abundant, and only a few are ever taken, for they frequent the deeper portions of streams and lakes, and are seldom seen except through periods of prolonged droughts when the retreating water leaves them stranded or in shallow pools.

LIZARDS.

The little blue-tailed lizards are present in large numbers and dart under some protecting object on the first approach of danger. Mountain-boomers are present in rough, hilly parts of the State where rocks abound, and the horny "toad," which is not a toad at all, but a lizard, is a common sight in practically every community of the State. A few small alligators have ascended the rivers as far as the central portion of Oklahoma. A specimen about four and a half feet long was taken from an over-flow lake south of Norman, and another was reported in a small lake near Durant. This is, of course, far outside the usual limits of their natural range, and it is one of the strange, interesting experiments of Nature in thus projecting an animal into a habitat remote from its established home, and under conditions that require radical changes in its manner of living if it is to survive.

INSECTS.

Why is an insect? This question has always been uppermost in the minds of farmers, while gardeners and fruit growers have never ceased to speculate on what a paradise this world would be if insects had never been created. Dwellers in antiquated hotels give eloquent testimony of the annoyance and humiliation caused by certain of these lowly animals, and the inhabitants of swampy regions know only too well of the deadly malaria that abounds and claims many human victims in regions that are infected with the Anophiles mosquito. Texas fever is transmitted through the bite of a tick, and is responsible each year for a loss in this State that cannot be expressed with less than six figures. The inconvenience and suffering resulting directly or indirectly from the housefly and the diseases which it spreads represent an economic loss that can scarcely be overestimated. Forests in all parts of the State are being weakened by the ravages of insect pests, and it is a common sight to see orchards destroyed and turned into cultivated fields, because the farmers could not compete sucessfully with the hordes of pests that find an easy food supply in the young fruit trees. Those people who were in the State in 1907 remember well how the greenbugs came early in the spring and settled like dust over the wheat fields. They remained until harvest time and destroyed about twenty percent of the wheat crop in Oklahoma. The destruction and waste occasioned by insects each year in this State amounts to more than $40,000,000. This is an economic waste that in time can be and must be controlled. Before the coming of the settlers there were no such things as insect plagues, but man has entirely upset the balance of Nature, and has made possible the unlimited production of these pests by killing or driving away their natural enemies, and providing in the cultivated crops a food supply that would not be possible in the wild order of things. Insects can be checked and reduced to proportions where they can inflict little harm. The United States Department of Agriculture has already provided and tested the methods, but one man working alone cannot do it; a county alone cannot, but the whole State working as an organized unit can, if it will, arouse itself, and by scientific methods strike forever from the ledger this annual waste of millions.

SUMMARY.

Communities in their regard for animal life undergo the usual cycle of development. There are at first the boyhood days, when the primitive instincts to kill and destroy are dominant, and indiscriminate slaughter is the order of the day. Buffaloes are shot from car windows, fish ponds are dynamited during spawning seasons, and song birds are sacrificed by the hundreds for rifle practice. We have now, happily, passed this barbarous age and are living in the young manhood period when some prudence is exercised and some restrictions imposed, but when the spirit of carelessness and indifference prevents the expression of some of the noblest impulses, and keeps us inactive even after we know the truth and have sensed our responsibilities. Let us hope that this State is soon to emerge into the period of mature manhood, characterized by a deep sense of our obligation to wild life, and a resolute determination to make reparation, as far as possible, for the blunders of the past, by preserving and increasing the wild things that yet remain, and to pass them on undiminished to the future generations.

CLASSIFIED LIST OF WILD ANIMALS IN OKLAHOMA.

The following is an annotated check list of the vertebrated animals ccuring in Oklahoma. It is intended only as a preliminary list and is y no means complete. In its preparation the writer has been conervative and included only those species which, from authentic published records or personal experience, he knows are residents of this State.

Those animals which have recently been exterminated or occur only in captivity are indicated by an asterisk (*).

The order in which the species are listed is the one which was thought would be the most convenient for the average reader. The scientific names are given for the convenience of those who may wish to check this list with the animals in other states, where the common names differ widely from those of our own.

MAMMALS. CLASS MAMMALIA.

HOOFED ANIMALS. ORDER ARTIODACTYLA.

Buffalo. (American bison.)
Bison bison.
Whitetail deer. (Virginia deer.)
Odocoileus virginianus.
Antelope. (Prongbuck.)
Antilocapra americana.
*Elk. (Wapiti.)
Cervus canadensis.
Mule deer. (Black-tailed deer.)
Odocoileus heminous.

FLESH-EATING ANIMALS. ORDER CARNIVORA.

Mountain lion. (Puma. Cougar.)
Felis concolor.
Ocelot. (Leopard cat. Tiger cat.)
Felis pardalis.
Coyote. (Prairie wolf.)
Canis latrans.
Red fox.
Vulpes fulvus.

*Kit fox. (Swift fox.)
Vulpes velox.
Gray fox.
Urocyon cinereoargenteus.
Otter.
Lutra canadensis.
Weasel. (Long tailed weasel.)
Putorius longicauda.
Mink.
Lutreola vison.

Bobcat. (Wild cat. Red lynx.)
Lynx rufus.
Gray wolf. (Timber wolf.)
Canis occidentalis.
Common skunk.
Mephitis mesomelas.
Little spotted skunk.
(Hydrophobia cat.)
Spilogale interrupta.
Badger.
Taxidea berlandieri.
Black Bear.
Ursus americanus.
*Grizzly bear. (Silver-tip g
Ursus horribilius.
Raccoon.
Procyon lotor.

GNAWING ANIMALS. ORDER GLIRES. RODENTIA.

aver.
Castor texonsis.
d squirrel. (Chickaree.)
Sciurus hudsonicus.
ay squirrel.
Sciurus carolinensis.
ipmunk. (Rock squirrel.)
Tamias striatus.
riped ground squirrel.
(Thirteen-lined, or Leopard Spermophile.)
Citellus tridecemlineatus.
anklin ground squirrel. (Gray ground squirrel.)
Citellus franklini.
airie dog.
Cynomys ludovicianus.
ound hog. (Woodchuck.)
Marmota monax.
ying squirrel.
Sciuropterus querceti.
hite-footed prairie mouse.
Peromyscus maniculatus bairdi.
eld mouse.
Microtus ludovicianus.
arvest mouse.
Reithrodontomys dychei.

Small flying squirrel.
Sciuropterus volans.
Muskrate.
Fiber zibethicus.
Wood rat. (Pack rat.)
Neotoma macropus surberi.
Cotton rat. (Marsh rat.)
Sigmodon hispidus texianus.
Meadow vole.
Microtus austerus.
Wood vole.
Microtus pinetorum.
Pocket mouse.
Perognathus paradoxus.

Grasshopper mouse.
Onychomys leucogaster.
Kangaroo rat.
Microdipodops richardsoni.
Deer mouse.
Peromyscus atwateri.
Cotton mouse.
Reithrodontomys chrysotis.
Pocket gopher.
Geomys breviceps.
Prairie mouse.
Peromyscus canus.

RABBITS. FAMILY LEPORIDAE.

tton-tail.
Lepus sylvaticus.

mmon jack rabbit. (Jack hare.)
Lepus texianus.

Whitetailed jack rabbit.
(Prairie hare.)
Lepus campestris.

INSECT-EATING ANIMALS. ORDER INSECTIVORA.

mmon mole.
Scadops aquaticus.

Prairie mole. (Silver mole.)
Scalops sp.
Short-tailed shrew.
Blarina brevicauda.

BATS. ORDER CHIROPTERA.

tle brown bat.
Myotis lucifugus.
brown bat.
Eptesicus fuscus.

Big-eared bat.
Myotis sublatus.
Tree bat. (Red bat.)
Lasiurus borealis.

POUCHED MAMMALS. ORDER MARSUPIALIA.

Virginia Opossum. ('Possum.)
Didelphis virginiana.

*Murine Opossum.
(Mouse Opossum.)
Marmosa murina.

*A tropical species accidentally introduced in bananas. Has been tal at Yukon (2 specimens) and at Norman (13 specimens).

BIRDS. CLASS AVES.

GREBES.

Pied-bill grebe. ("Hell-diver." Dab-chick.)
Podilymbus podiceps.

LOONS.

Great northern diver. (Loon.)
Gavia imber.

GULLS AND TERNS.

Franklin's rosy gull.
Larus franklini.

Herring gull.
Larus argentatus.

Least tern.
Sterna antillarum.

CORMORANTS.

Double-crested cormorant.
Phalacrocorax auritus.

PELICANS.

Great white pelican.
Pelecanus erythrorphynchos.

DARTERS.

Snake-bird. (Darter. Water-turkey. Anhinga.)
Anhinga anhinga.

GEESE, DUCKS, AND SWANS.

American merganser.
Mergus americanus.
Hooded merganser.
Lophodytes cucullatus.
Mallard.
Anas platyrhynchos.
Black duck.
Anas rubripes.

Canvasback.
Marila valisineria.
Lesser scaup duck.
Marila affinis.
American golden-eye.
Clangula americana.
Buffhead.
Charitonetta albeola.

adwall.
Chaulelasmus streperus.

ldpate.
Mareca americana.

reenwinged teal.
Nettion carolinense.

luewinged teal.
Querquedula discors.

oveller.
Spatula clypeata.

ntail. (Sprig.)
Dafila acuta.

ood duck.
Aix sponsa.

edhead.
Marila americana.

reater scaup duck.
Marila marila.

ingnecked duck.
Marila collaris.

Ruddy duck.
Erismatura jamaicensis.

Lesser snow goose.
Chen hyperboreus.

Blue goose.
Chen caerulescens.

Whitefronted goose.
Anser albifrons gambeli.

Canada goose.
Branta canadensis.

Hutchins's goose.
Branta canadensis hutchinsi.

Smaller whitecheeked goose.
Branta c. occidentalis.

Fulvous tree duck.
Dendrocygna fulva.

Whistling swan.
Olor columbianus.

Trumpheter swan.
Olor buccinator.

IBISES, HERONS, AND EGRETS.

hitefaced glossy ibis.
Plegadis guarauna.

merican bittern.
Botaurus lentiginosus.

east bittern.
Ixobrychus exilis.

reat blue heron.
Ardea herodias.

Little green heron.
Butorides virescens.

*Snowy heron. (Snowy egret.)
Egretta candidissima.

Blackcrowned night heron.
Nycticorax nycticorax.

Yellowcrowned night heron.
Nyctanassa violacea.

Little blue heron.
Florida caerulea.

CRANES AND RAILS.

Vhooping crane.
Grus americana.

ttle brown crane.
Grus canadensis.

ndhill crane.
Grus mexicana.

ing rail.
Rallus elegans.

Sora.
Porzana carolina.

American coot. (Mudhen.)
Fulica americana.

American avocet.
Recurvirostra americana.

Blacknecked stilt.
Himantopus mexicanus.

SNIPES.

ilson's snipe.
Gallinago delicata.

Yellowlegs.
Totanus flavipes.

Pectoral sandpiper.
Pisobia maculata.
Least sandpiper.
Pisobia minutilla.
Semipalmated sandpiper.
Ereunetes pusillus.
Upland plover. (Bartramian sandpiper.)
Bartramia longicauda.
Marbled godwit.
Limosa fedoa.
Solitary sandpiper.
Helodromas solitarius.
Western willet.
Catoptrophorus semipalmatus inornatus.
Spotted sandpiper.
Actitis macularia.
Longbilled curlew.
Numenius americanus.
*Eskimo curlew.
Numenius borealis.
Wilson's phalarope.
Steganopus tricolor.

PLOVERS.

Blackbellied plover.
Squatarola squatarola.
Snowy plover.
Aegialitis nivosa.
Kildeer.
Oxyechus vociferus.

GROUSE, PARTRIDGE, ETC.

Bobwhite.
Colinus virginanus.
Western blue quail.
Callipepla squamata.
Prairie chicken.
Tympanuchus americanus.
Lesser prairie hen.
Tympanuchus pallidicinctus.

TURKEY.

Wild turkey.
Melleagris gallopavo.

PIGEONS.

Mourning dove.
Zenaidura macroura.
*Passenger pigeon.
Ectopistes migratorius.
Bandtailed pigeon.
Columba fasciata.

VULTURES.

Black vulture.
Catharista urubu.
Turkey vulture. (Turkey "Buzzard.")
Cathartes aura.

FALCONS AND HAWKS.

Mississippi kite.
Ictinia mississippiensis.
Cooper's hawk.
Accipiter cooperi.

Marsh hawk.
Circus hudsonius.
Sharp-shinned hawk.
Accipiter velox.
Red-tailed hawk.
Buteo borealis.
Harlan's hawk.
Buteo b. harlani.
Red-shouldered hawk.
Buteo lineatus.
Swainson's hawk.
Buteo swainsoni.
Goshawk.
Astur atricapillus.
Krider's hawk.
Buteo borealis krideri.
Ferruginous rough-leg hawk.
Archibuteo ferrugineus.
Sparrow hawk.
Falco sparverius.
Osprey.
Pandion haliaetus.
Prairie falcon.
Falco mexicanus.
Rough-legged hawk.
Archibuteo lagopus.

EAGLES.

Golden eagle.
Aquila chrysaetos.
Bald eagle.
Haliaetus leucocephalus.

OWLS.

Barn owl. (Monkey-face owl.)
Aluco pratincola.
Short-eared owl.
Asio flammeus.
Barred owl.
Strix varia.
Screech owl.
Otus asio.
Burrowing owl.
Speotyto cunicularia.
Western horned owl.
Bubo virginianus pallescens.

PAROQUETS.

*Carolina paroquet.
Conuropsis carolinensis.

CUCKOOS.

Road-runner. (Chaparral Cock.)
Geococcyx californianus.
Black-billed cuckoo.
Coccyzus erythrophthalmus.
Yellow-billed cuckoo. (Rain-crow.)
Coccyzus americanus.

KINGFISHERS.

Belted kingfisher.
Ceryle alcyon.
Texas kingfisher.
Ceryle americana.

WOODPECKERS.

Hairy woodpecker.
Dryobates villosus.
Red-shafted flicker.
Colaptes cafer collaris.

Southern downy woodpecker.
Dryobates pubescens.
Red-bellied woodpecker.
Centurus carolinus.
Yellow-bellied sapsucker.
Sphyrapicus varius.
Red-headed woodpecker.
Melanerpes erythrocephalus.
Yellow-shafted flicker.
Colaptes auratus.
Pileated woodpecker.
Phloeotomus pileatus.
Texas woodpecker.
Dryobates scalaris.
Ivory-billed woodpecker.
Campephilus principalis.

GOATSUCKERS.

Whip-poor-will.
Antrostomus vociferus.
Chuck-will's-widow.
Antrostomus carolinensis.
Nighthawk.
Phalaenoptilus nuttallii.
Poor-will.
Chordeiles virginianus.

SWIFTS.

Chimney swift.
Chaetura pelagica.

HUMMING-BIRDS.

Ruby-throated humming-bird.
Archilochus colubris.

PERCHING BIRDS.

FLYCATCHERS.

Scissor-tailed flycatcher.
Muscivora forficata.
King-bird.
Tyrannus tyrannus.
Trail's flycatcher.
Empidonax trailli.
Olive-sided flycatcher.
Nuttallornis borealis.
Phoebe.
Sayornis phoebe.

Wood pewee.
Myiochanes virens.
Arkansas king-bird.
Tyrannus verticalis.
Crested flycatcher.
Myiarchus crinitus.
Yellow-bellied flycatcher.
Empidonax flaviventris.
Least flycatcher.
Empidonax minimus.
Green-crested flycatcher.
(Acadian flycatcher.)
Empidonax virescens.
Vermilion flycatcher.
Pyrocephalus rubinus.
Say's phoebe.
Sayornis saya.

LARKS.

Horned lark.
Otocoris alpestris.
Prairie horned lark.
Otocoris a. praticola.
Desert horned lark.
Otocoris a. lucolaema.

CROWS AND JAYS.

lue jay
Cyanocitta cristata.
merican magpie.
Pica pica hudsonica.
White-necked raven.
Corvus cryptoleucus.
American crow.
Corvus brachyrhynchos.

BLACKBIRDS AND ORIOLES.

obolink.
Dolichonyx oryzivorus.
owbird.
Molothrus ater.
ellow-headed blackbird.
Xanthocephalus xanthocephalus.
ed-winged blackbird.
Agelaius phoeniceus.
eadowlark.
Sturnella magna.
estern meadowlark.
Sturnella neglecta.
Orchard oriole.
Icterus spurius.
Baltimore oriole.
Icterus galbula.
Rusty blackbird.
Euphagus carolinus.
Brewer's blackbird.
Euphagus cyanocephalus.
Purple grackle.
Quiscalus quiscula.
Bronzed grackle.
Quiscalus quiscula aeneus.

FINCHES AND SPARROWS.

urple finch.
Carpodacus purpureus.
merican cross bill.
Loxia curvirostra.
merican goldfinch.
Astragalinus tritis.
rizona goldfinch.
Astragalinus psaltria.
ne siskin.
Spinus pinus.
apland longspur.
Calcarius lapponicus.
nglish sparrow. (House sparrow.)
Passer domesticus.
esper sparrow.
Pooecetes gramineus.
estern vesper sparrow.
Pooecetes gramineus confinis.
vannah sparrow.
Passerculus sandvichensis savanna.
estern Savannah sparrow.
Passerculus s. alaudinus.
ardinal.
Cardinalis cardinalis.
ose-breasted grosbeak.
Zamelodia ludoviciana.
Western grasshopper sparrow.
Coturniculus savannarum.
Baird's sparrow.
Centronyx bairdii.
Lark sparrow.
Chondestes grammacus.
Harris's sparrow.
Zonotrichia querula.
White-crowned sparrow.
Zonotrichia leucophrys.
Chipping sparrow.
Spizella passerina.
Field sparrow.
Spizella pusilla.
Slate-colored junco.
Junco hyemalis.
Song sparrow.
Melospiza melodia.
Lincoln sparrow.
Melospiza lincolni.
Fox sparrow.
Passerella iliaca.
Towhee.
Pipilo erythrophthalmus.
Lasuli bunting.
Cyanospiza amoena.

Blue grosbeak.
Guiraca caerulea.
Western blue grosbeak.
Guiraca c. lazula.
Indigo bunting.
Cyanospiza cyanea.
Painted bunting.
Cyanospiza ciris.
Dickcissel.
Spiza americana.
Lark bunting.
Calamospiza melanocorys

TANAGERS.

Scarlet tanager.
Piranga erythromelas.
Summer tanager.
Piranga rubra.

SWALLOWS.

Purple martin.
Progne subis.
Cliff swallow.
Petrochelidon lunifrons.
Barn swallow.
Hirundo erythrogaster.
Bank swallow.
Riparia riparia.

WAXWING.

Cedar waxwing.
Bombycilla cedrorum.

SHRIKES.

Northern shrike.
Lanius borealis.
Loggerhead shrike.
Lanius ludovicianus.

VIREO.

Red-eyed vireo.
Vireosylva olivacea.
Warbling vireo.
Vireosylva gilva.
Yellow-throated vireo.
Lanivireo flavifrons.
White-eyed vireo.
Vireo noveboracensis.
Small white-eyed vireo.
Vireo n. micrus.
Black-capped vireo.
Vireo atricapillus.

WARBLERS.

Black and white warbler.
Mniotilta varia.
Worm-eating warbler.
Helmitheros vermivorus.
Golden-winged warbler.
Vermivora chrysoptera.
Nashville warbler.
Vermivora rubricapilla.
Tennessee warbler.
Vermivora peregrina.
Audubon's warbler.
Dendroica auduboni.
Pine warbler.
Dendroica vigorsii.
Parula warbler.
Compsothlypis americana.
Yellow warbler.
Dendroica aestiva.
Myrtle warbler.
Dendroica coronata.
Palm warbler.
Dendroica palmarum.
Ovenbird.
Seiurus aurocapillus.
Water thrush.
Seiurus noveboracensis.
Louisiana water thrush.
Seiurus motacilla.
Kentucky warbler.
Oporornis formosa.
Mourning warbler.
Oporornis philadelphia.
Northern yellow-throated warbler.
Geothlypis trichas.
Yellow-breasted chat.
Icteria virens.

Black-throated blue warbler.
Dendroica caerulescens.
Black-poll warbler.
Dendroica striata.
Black-throated green warbler.
Dendroica virens.
Cerulean warbler.
Dendroica caerulea.
Hooded warbler.
Wilsonia citrina.
Canadian warbler.
Wilsonia canadensis.
American red-start.
Setophaga ruticilla.
Wilson's warbler.
Wilsonia pusilla.
Magnolia warbler.
Dendroica magnolia.

PIPITS.

American pipit.
Anthus rubescens.
Sprague's pipit.
Anthus spraguei.

DIPPER.

American dipper.
Cinclus mexicanus.

THASHERS AND WRENS.

Mockingbird.
Mimus polyglottos.
Western mockingbird.
Mimus p. leucopterus.
Cat-bird.
Dumetella carolinensis.
Brown thrasher.
Toxostoma rufum.
Bewick wren.
Thryomanes bewicki.
House wren.
Troglodytes aedon.
Winter wren.
Nannus hiemalis.
Western marsh wren.
Telmatodytes palustris.
Rock wren.
Salpinctes obsoletus.

CREEPERS.

Brown creeper.
Certhia familiaris americana.

NUTHATCHES.

White-breased nuthatch.
Sitta carolinensis.
Slender-billed nuthatch.
Sitta c. aculeata.
Tufted titmouse.
Baeolophus bicolor.
Black-capped chickadee.
Penthestes atricapillus.

KINGLETS.

Golden crowned kinglet.
Regulus satrapa.
Blue-gray gnatcatcher.
Polioptila caerulea.
Ruby Crowned kinglet.
Regulus calendula.

THRUSHES.

Wood thrush.
Hylocichla mustelina.
Gray-cheeked thrush.
Hylociclia aliciae.

Wilson thrush.
Hylocichla fuscescens.
Hermit thrush.
Hylocichla guttata pallasii.
American robin.
Planesticus migratorius.
Bluebird.
Sialia sialis.
Western or mountain bluebird.
Sialia artica.

REPTILES. CLASS REPTILIA.

POISONOUS SNAKES.

Diamond-backed rattlesnake.
Crotalus adamanteus.
Prairie rattlesnake.
Crotalus confluentus.
Timber rattlesnake.
Crotalus horridus.
Massasauga.
Sistrurus catenatus.
Edward's massasauga.
Sistrurus catenatus edwardsii.
Cotton-mouthed moccasin.
Ancistrodon piscivorus.
Copperhead.
Ancistrodon contortrix.
Coral snake.
Elaps fulvius.

HARMLESS SNAKES.

King snake.
Ophibolus getulus.
Yellow-bellied king snake.
Ophibolus caligaster.
Corn or rat snake.
Coluber guttatus.
Pilot snake.
Coluber obsoletus.
Black snake. ("Blue racer.")
Zamenis constrictor.
Bull snake.
Pituophis sayi.
Coach whip snake.
Zamenis flagelliformis.
Blow snake.
Heterodon nasicus.
Green snake.
Cyclophis aestivus.
Common water snake.
Tropidonotus fasciatus.
Worm snake.
Carphophiops vermes.
Insect snake.
Diadophis amabilis.
"Dryland" moccasin.
Tropidonotus rhombifer.
Texas blind snake.
Glauconia dulcis.
Spreading adder.
Heterodon platyrhinus.

ALLIGATOR.

Alligator mississippiensis.

LIZARDS.

Blue-tailed lizard.
Eumeces quinquelineatus.
Sonora skink.
Eumeces obsoletus.
Clark's swift.
Sceloporus clarkii.
Horned lizard. (Horned "toad.")
Phrynosoma cornutum.

Common spotted lizard.
Holbrookia maculata.
Glass "snake."
Ophiosaurus ventralis.
Mountain boomer.
Crotaphytus collaris.

TURTLES AND TORTOISES.

Snapping turtle.
Chelydra serpentina.
Alligator snapping turtle.
Macrochelys lacertina.
Common musk turtle.
Aromochelys odoratus.
Keeled musk turtle.
Aromochelys carinatus.
Mud turtle.
Cinosternum pennsylvanicum.
Common box turtle.
Cistudo carolina.
Gopher tortoise.
Testudo polyphemus.
Agassiz's tortoise.
Testudo agassizi.
Southern soft-shelled turtle.
Trionyx ferox.
Spiny soft-shelled turtle.
Trionyx spinifer.
Diamond-back terrapin.
Malacoclemmys palustris.

AMPHIBIANS. CLASS AMPHIBIA.

TOADS.

Western spadefoot toad.
Scaphiolpus hammondii.
Common toad.
Bufo cognatus.
American toad.
Bufo americanus.
Toad.
Bufo compactilis.

FROGS.

Tree frog.
Hyla versicolor.
Cricket frog.
Acris gryllus.
Southern leopard frog.
Rana sphenocephala.
Southern tree frog.
Hyla squirrella.
Leopard frog.
Rana pipiens.
Green frog.
Rana clamitans.
Common bull frog.
Rana catesbiana.

SALAMANDERS.

Tiger salamander. (Axolotl. Mudpuppy. Water-dog.)
Amblystoma tigrinum.

FISHES. CLASS PISCES.

Lake sturgeon.
Acipenser rubicundus.
Shovel-nosed sturgeon.
Scaphirhynchus platyrhynchus.
Mississippi blue cat.
Ictalurus furcatus.
Channel catfish.
Ictalurus punctatus.
Bullhead.
Ameiurus nebulosus.
Yellow cat.
Ameiurus natalis
Mud cat.
Leptops olivaris.
Common sucker.
Catostomus commersoni.
Hickory shad.
Dorocoma cepedianum.
Large-mouthed black bass.
Micropterus salmoides.
Yellow perch.
Perca flavescens.
Goggle-eye.
Ambloplites rupestris.
Sunfish.
Eupomotis gibbosus.
Long-nosed gar pike.
Lepidosteus osseus.
Black-gill sunfish.
Lepomis pallidus.
Buffalo.
Ictiobus cyprinella.
Common eel.
Anguilla chrisypa.

CHAPTER II.

PLANT LIFE IN OKLAHOMA.*

INTRODUCTION.

Oklahoma is an especially interesting region botanically, being a transition area between typical Mississippi Valley conditions in its eastern part, and very different conditions in the foot-hill region of the Rocky Mountains. The relation to the flora of the Gulf Plain and the more northern floras within its area is of much importance, since many species of both regions reach the limits of their ranges within the boundaries of the State.

Compared with the eastern states, Oklahoma is large, the area being 70,470 square miles, or more than the combined areas of the six New England states and New Jersey. Oklahoma extends from about 94° 30′ west longitude westward to 103° west longitude and from 33° 38′ north latitude to 37°. Its form is roughly rectangular with a narrow westward extension from the northwest corner, known as the Panhandle of the State.

PHYSIOGRAPHY AND GEOLOGY.

The lowest elevation in the State is in the southeastern corner, where the distance above sea level is about 400 feet. The surface rises gradually to the north and northwest, reaching an elevation of more than 4,000 feet in the west end of the Panhandle. Along the eastern edge of Leflore County, near the southeastern corner of the State, the high elevation of the hilly region, lying between the Ozark Mountains and the Ouchita Mountain uplift, extends from Arkansas into the State, the highest point being on Rich Mountain near Page, with an elevation of about 2,000 feet above sea level. Gradually lower elevations extend westward for about 50 miles. The northern third of the eastern part of the State lies in the western end of the Ozark range, and in some places along the State line the elevation reaches 1,000 to 1,500 feet.

About 30 miles north of Red River, and almost midway along the south side of the State, the Arbuckle Mountains are found, and extend for about 30 miles in a general east and west direction. In the southwestern corner of the State, approximately 30 miles from both the west line and Red River, the Wichita Mountains rise abruptly. These mountains consist of a series of hills and mountains of granite, porphyry, and limestone which extend southeastward nearly parallel with the general course of Red River for about 60 miles, gradually increasing in elevation to the east end of the range, where the greatest height is attained in Mt. Scott, some 1,500 feet in elevation. The other portions of the State have few local elevations except the conspicuous ranges of gypsum hills through several counties in the western part of the main body of the State (Pl. XI). These bluffs and butts often stand conspicuously above the surrounding regions, but their elevations do not exceed that of the more level country lying west of them.

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*Stevens, G. W. and Shannon, C. W.—See "Introduction" page 5.

West of the Gypsum Hills region, the surface is higher and more nearly even, except where cut into valleys and canyons by the nearly parallel rivers. and the surface of the region passes gradually into the Great Plains at about the 100th meridian.

Lying along the north side of the valleys of four rivers in the northwestern part of the State are belts of sand hills, ranging from 2 to 18 miles in width (Pl. VII). In the counties along the 100th meridian, the sandy regions, in some places, extend on both sides of the valleys, occasionally crossing the divides.

The surface of the strip 15 to 40 miles broad, extending from the southeastern corner of the State westward to about the middle of the south side, is a part of the Gulf Coastal Plain and consists of Cretaceous formations. The surface rocks of some areas in the Panhandle part of the State, and the western parts of Cimarron County, are also Cretaceous. The eastern half of the State, with the exception of the Ouachita and Arbuckle mountain uplifts, and the Cretaceous area along Red River, is included in the Carboniferous formations. The extreme northeastern part of the State, north of the Arkansas and east of Grand River, is composed of rocks chiefly of Mississippian age, while the remainder of the area designated consists of rocks of Pennsylvanian age. From about the middle line of the State, westward, with the exception of the Wichita Mountain region, and the High Plains area, the rocks belong to the Permian Redbeds. The surface rocks of the High Plains region consist principally of Cretaceous and Tertiary formations, with considerable areas covered by sands of recent age.

SALT PLAINS.

Low lying level sandy tracts varying from one acre to 50 square miles in area and having salt springs at or under the surface are known as salt plains. These are all in the western third of the State, and are mostly located far apart, although in three instances two or three are grouped in rather close proximity. The saline condition of these plains is due probably in all cases to the presence of salt springs.* However, the existence of such springs has not been demonstrated in the Great Salt Plains or United States Saline Reserve, in Alfalfa County; but the constant presence of salt water in the sandy floor even in the summer when evaporation is very great, strongly suggests the presence of saline springs beneath the floor of the plain. At this period the surface becomes white with an incrustation of salt. In most of the other salt plains the salt springs are flowing onto the surface, and the evaporation results in a crust of salt sometimes several inches thick on parts of the floor of the plain. One of these, in the valley of the Cimarron River, known as the Big Salt Plain of the Cimarron, beginning about 10 miles south of the Kansas line and extending about 8 miles down the river, is "the only place where rock salt can be obtained on the surface in all the plains country. This salt was known and used by the Indians, and was an article of trade from the Gulf to the British line, and this locality was a well-known geographical point from which distances were reckoned."* On several of the others salt is abundant and has been manufactured for local market at three or four of them.

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*Okla. Geol. Survey Bull. No. 11, Chap. VI. page 202.

The most conspicuous biological feature of the Salt Plains is the almost complete absence of life either in the water or soil. In some of the less concentrated ponds ditch grass (*Ruppia maritima*) is found. About their margins are found cat-tail (*Typha angustifolia*), bug-seed (*Corispermum hyssopifolium*), tumble-weed (*Cycloloma antriplicifolium*), sea-blite (*Suaeda linearis*), and water rush (*Scirpus campestris var. pludosus*); while sea purslane (*Sesuvium sesile*) grows in the salty sand of the floor plains. Salt grass, (*Distichlis spicata*), water-rush (*Ssirpus Torrey*), rush grass (*Sporobolus airoides*), and sand rache (*Atriplex argentea*) are found about the margins, but are occasionally likewise in other less alkaline parts of the State. Salt-marsh fleabane (*Pluchea camphorata*) is occasionally found in slightly alkaline situations about the plains and is not reported elsewhere in the State.

The size of the Great Salt Plain, about 12 miles long and 6 miles across in the broadest place, and its low position within a rather extended basin, lead to the belief that it is the site of an ancient lake which is called Lake Barde. The presence of the Least Tern nesting regularly in considerable numbers upon this plain and the Big and Little Salt plains of the Cimarron is taken by ornithologists as evidence of a former inland sea in the vicinity. This is a sea coast bird found rarely elsewhere except on the Florida, Gulf, and Lower California coasts.

GYPSUM HILLS.

Two formations of gypsum occur in the western part of the State (Pl. XI). These are exposed along the juncture of valleys and higher tracts, and mostly have the form of bluffs and buttes, the latter frequently called Glass Mountains or Gloss Mountains. The gypsum caps, on the bluffs or butts preserve the top of the elevation, with their slow decaying rock, while the underlying red clay is eroded more rapidly, often leaving perpendicular faces. (See Plate XX.) The rapid erosion of the sides of these hills and the excess of calcium sulphate (gypsum) on their tops make unfavorable conditions for plants. A few species are usually found on and about them and some of these are mostly not found elsewhere.

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*Okla. Geol. Survey Bull. No. 11, p. 205.

The most exclusively gypsum hill species are plains psilostrophe (*Psilostrophe villosa*), and phacelia (*Phacelia intergrifolia,*) and few-seeded mentzelia (*Mentzelia oligosperma*) which grow on the top of the gypsum cap or the last species in clefts in it; Nama (*Nama compactum*) seems to be confined almost exclusively to the guttered and weathered sides of these hills, the type locality of the species being the side of the butte in Major County known as Gloss Mountain. The sharp-scaled grass (*Erioneuron pilosum*) is common on somewhat more permanent places on the sides of the bluffs and is seen growing at the mouth of the cave in the illustration (Pl. XXI). Evening primrose (*Oenothera missouriensis*), sensitive brier (*Mimosa borealis*). aster (*Aster aricaefolius*), evening primrose (*Oenothera Hartwegi var. lavendulaefolia*), hairy purslane (*Portulaca polisa*), vetch (*Astragalus parviflorus*), and (*A. cuspidata*) are found about the sides and bases of the hills, but they also occur in other locations having red clay soil with a large content of calcium sulphate. The wild gooseberry (*Ribes aurea*), ill-scented sumac (*Rhus canadensis var. trilobata*), and red cedar (*Juniperus virginiana*) are often found rooting in the clefts of the gypsum cap, but are as often found in soil not especially rich in gypsum.

SAND-HILLS REGION.

Beginning about the middle of the State or a little farther westward there extends a strip of sandy country along the north side of each of four nearly parallel rivers, the Salt Fork of the Arkansas, Cimarron, North Canadian, and South Canadian (Pl. VII). These areas are from 2 to 18 miles broad and stretch northwestrly 50 to 210 miles. Near the western edge of the State the sandy area along the South Canadian broadens and becomes continuous on the north with that of Wolf Creek, a tributary of the North Canadian. and extending southward continues to Washita River. Farther southward along the western edge of the State exteneive sandy regions are encountered on both sides of Salt Fork and North Fork of Red River, and east of the latter near its junction with Red River.

The sandy regions along the rivers in the northwestern part of the State seem to owe their origin to certain weather conditions which have maintained for a long period in the past, and to some extent are still operating.

These rivers are relatively long, the Cimarron and South Canadian having their sources in the Rocky Mountains. The rains in a semi-arid country are usually more rapid and of shorter duration than in better watered regions. In western Oklahoma formerly many rains lasted from 15 minutes to an hour. precipitating in that time from 1 to 4 inches of water. The uncultivated condition of the soil and the short duration of the rain resulted in most of the water running off and leaving, it is estimated, in some instances, as little as 10 per cent of it in the soil. The erosion caused by the resulting freshets and floods was great and the intensely muddy water of the streams carried much sand. The clay and dissolved substances were mostly carried on to larger rivers, but the sand was dropped in the river bed in the shape of bars as the velocity of the water diminished. Long periods of dry weather often intervened between rains, and in these drouth periods the rivers often became completely dry. During the summer dry periods the wind blows almost constantly from the south and has a velocity of from 10 to 40 miles per hour. The finer sand is carried by such wind and during most of the time, probably, since the Tertiary period, the winds have been strewing northward much of the sand brought down by the spring freshets. The area in the State thus covered by the sand from these four rivers is estimated to be between 3,000 and 4,000 square miles.

The average rainfall here has not increased in the last few decades, but the cultivation of the soil and growing of crops and trees since the settlement of the country have resulted apparently in the rainfall occurring more gently and for longer duration. This fact, together with the receptive condition of the soil caused by cultivation, results in a much larger part of the precipitation entering the soil and in fewer freshets and floods as well as less erosion. The sand supply of the river beds is no longer greatly increased and the sand is mostly kept moist during the summer and not carried by the wind. These rivers are now seldom dry and the areas of shifting sand are much reduced. In a few places the sand still drifts during the summer. In the southwestern part of Woods County, there are several square miles covered with shifting dunes and the region is advancing northward covering elm and cottonwood trees and causing Dog Creek to change its course.

The plant life of the sand-hills consists of fewer species than that of the adjacent non-sandy regions, the number being greatest along the margins of the sandy areas, in better watered places and on sand-hills where sand has long since stopped drifting. The Waynoka dunes, some of which are 75 feet high, have no plant life except an occasional top of a buried cottonwood still projecting above the drifting surface.

BLACK MESA REGION.

Where the Cimarron River enters the northwestern corner of the State it traverses a rather deep valley or broad canyon bounded by sandstone-capped bluffs and buttes on the south and by the Black Mesa on the north. The Black Mesa is a bed of lava or mal pais rock, now standing above the level of neighboring elevations. The flora is distinctly western.

SOILS.

The great variety of rock formations found in the regions above named produces soils differing much in character. The granites, limestones, sandstones, shales, and clays each make different types of soil.

The soils of the State may be grouped under the following heads: (1) Residual soils; (2) Transported soils. Under the second type are: (a) Colluvial soils; (b) Alluvial soils; (c) Aeolian soils. Residual soils are those which have been formed in the place where they are now found, and the soils of Oklahoma belong chiefly to this type. The transported soils of the State consist of those along the streams and the sand areas of the State. The eastern half of the State has limestone generally present in the soil. The western half has an abundance, and even an excess of gypsum, even in the sand hill areas which are in the general gypsum region. The ground water also contains gypsum, and wells in the Permian red clay often furnish water so strong with gypsum that farmers must depend upon cisterns for holding water for domestic purposes. A large percentage of the soils of the State are alkaline. The percentage of acid soils is relatively small.

PRECIPITATION.

The rainfall is greatest in the southeastern part of the State, where it averages about 43 inches per year, gradually diminishing westward to Cimarron County, where the average is only 15 inches per year. A considerable part of the central-western part of the State also has a scanty rainfall. For further information concerning the precipitation, the reader is referred to a discussion of rainfall on page 37.

Lines marking places of equal rainfall extend mostly a little west of south from the northern boundary of the State.

LIFE ZONES.

Four life zones have been distinguished in Oklahoma. The Upper Austral covers a small area at the middle of the north edge and most of the Panhandle. The Carolinian zone extends over the rough and elevated regions in the eastern part of the State. The Lower Austral zone covers the central and a part of the eastern portions, while about two-thirds of the eastern portion is in the Austroriparian. These regions pass imperceptibly into each other, except in a few cases, where the change is rather abrupt (the Carolinian having rather distinct lines of contact with the Austroriparian).

RELATION OF PHYSICAL CONDITIONS TO THE FLORA.

In Oklahoma the problem of determining the relation of the different types of soil, of the elevation (life zones), of rainfall, and of distributing agents to the distribution of our species is complicated and difficult. By reference to the maps contained in this report, it will be seen that the lines showing the limits of the geological formations, and lines of equal rainfall largely coincide, and that the lines of equal elevation also in a general way coincide with these. Along the line of junction between the Pennsylvanian and Permian formations, numerous species reach the limit of their western range in the State. Conspicuous among these are Syca-

more (*Platanus occidentales*), hickory (*Corya Illinoensis*), hickory (*Carya cordiformis,*) hackberry (*Celtis mississippiensis*), blackberry (*Rubus villosus*), black-cap raspberry (*Rubus occidentalis*), dwarf chestnut oak (*Quercus prinoides*), black oak (*Quercus veluntina*), southern red oak (*Quercus texana*), blue ash (*Fraxinus quadrangulata*), persimmon (*Diospryros virginiana*), winged elm (*Ulmus alata*), flowery dog wood (*Cornus florida*). Several of these extend somewhat father westward than the Pennsylvanian-Permian line in the southern part of the State. Since the lines of equal precipitation swing westward toward the southern end of the State, and the species named are found in their farthest west stations in places suffering less from evaporation than the average conditions of the regions (mountains, canyons, and river valleys), it seems that the governing factor of their western limits is the amount of moisture accessible in the soil and the relative freedom from excessive evaporation, rather than the nature of the soil.

There is a gradual thinning out of eastern species toward the western part of the State, the western limits of their ranges often extending as slender tongues along the valleys of the larger rivers, a fact which seems to point to the reduced moisture supply as the determining factor limiting their ranges. Prairie crab apple (*Pyrus ioensis*), Amercian hazelnut (*Corylus americana*), beech (*Fagus grandifolia*), hop hornbeam (*Ostrya virginiana*), cucumber tree (*Magnolia acuminata*), smooth alder (*alnus rugosa*), chinquapin (*Castanea pumila*), willow oak (*Quercus phellos*), water oak (*Quercus nigra*), are found but the division of the Carboniferous formations where they grow terminates mostly in a zone of precipitation between 37 and 40 inches, and since the range of most of these species includes regions of unlike soil conditions, but not any territory with less than 37 inches of annual rainfall, it seems to follow that the amount of precipitation is the governing condition. Aside from certain plans characteristic of special conditions to be described later, the delimiting factor in most of our plant ranges seems to be the amount of rainfall.

RELATION OF OUR FLORA TO THAT OF ADJACENT REGIONS.

The examination of the ranges of 1,000 of our species chosen as representatives shows the following facts concerning the relation of our flora to that of adjacent regions. This number of species was chosen rather than the entire number (about 1500) because the ranges of about one-third of them are broken, very irregular, or of such outline, such as introduced and vestigial species, as not to lend evidence in the present investigation. The results are given in the number of species per hundred of our range, minor fractions being omitted, and major fractions used as integers.

The flora is divided into groups as follows: (1) *Northern flora,* consisting of species whose southern range does not extend farther southward than Oklahoma (or rarely slightly farther), and divided into two groups: (a) species ranging through Upper Austral or the Carolinian and into the Transition or Alleghanian; and (b) species whose northern range limits lie in the Upper Austral or Carolinian. (2) ***Mid-Mississippi Valley flora,*** species ranging well into both the Upper Austral or Carolinian and the Lower Austral or Austroriparian. (3) ***Southern flora,*** consisting of species whose ranges are confined to the Lower Austral and Austroriparian, and divided into two groups: (a) those species ranging mostly through the lower Mississippi Valley, and (b), those species having ranges confined to Oklahoma, eastern Texas, and Louisiana. (4) ***Western species*** placed into two groups: (a) those whose ranges extend westward beyond the Upper Austral and into various zones beyond, and (b) those species confined to the Upper Austral zone (Great Plains). (5) Local species: (a) those species whose ranges do not extend beyond any adjacent state, and (b) those whose ranges are confined to Oklahoma. There is some duplication of species in division (3) group (b), and division (5) group (a), but the number is less than one per cent.

Approximately 5 per cent of our species are found throughout the State, or in other words, 19 out of 20 of our plants reach the limit of their ranges in Oklahoma. 70 per cent of our flora is the western extension of Mississippi Valley flora, and 7 per cent more is doubtless derived from the flora of that region. Twenty-one per cent is derived from the Great Plains or more westerly regions, and there are reasons for believing that about 2 per cent probably had local origin in Kansas, Oklahoma and Texas.

DISTRIBUTING AGENCIES.

The importance of distributing agencies is exaggerated in Oklahoma by the fact that 95 per cent of our species do not extend entirely over the State. The present distribution of many species is comparatively recent, for the details of their ranges are determined by local soil and water conditions that have been developed within a comparatively brief past. The western limits of many of our eastern species have numerous slender extensions or outlying stations in the regions west of them, these being mostly strips following the valleys and canyons of streams up their courses.

Two of the most generally distributed species in the State are Carolina poplar (*populus deltoides*), and long-leafed willow (*Salix longifolia*). Their wide range depends upon the facts that appropriate soil and moisture conditions for them exist over most of the State, and that the species have been able to reach the stations where now found. The wind is doubtless the agency responsible for the wide distribution of these, as well as for numerous others blown as tumble-weeds or whose seeds have pappus or coma of such nature as to enable them to be carried by the wind, notable examples being found among our composites and milkweeds.

As far as our eastern species are concerned, the consideration of water as a distributing agency may be discarded. Our rivers all flow south-easterly, and while they doubtless contribute to the distribution of some of our western species, they cannot assist those migrating westward.

Oklahoma is far enough south (33° 38′ to 37°) so that many birds which are only summer residents farther northward, such as Robins, Bluebirds, and Waxwings are common here in the winter, and subsist largely or partly upon various kinds of dried fruits. In summer many species of berry-eating and drupe-eating birds assist in the distribution, and as a result one or more species of hackberry (*Celtis*), plum (*Prunis*), grape (*Vitis*), Virginia creeper (*Parthenocissus*), soapberry (*Sapindus*), sumac (*Rhus*), greenbrier (*Smilax*), pokeweed (*Phytolacca*), Cedar (*Juniperus*), oak (*Quercus*), prickly pear (*Opuntia*), and *cactus* (*Mammillaria*) have found their way up valleys, into tributary and adjacent valleys or far out on the prairies.

The examination of numerous stomachs of cedar waxwings, robins, bluebirds, blackbirds, tanagers, orioles, mockingbirds, brown thrashers, catbirds, and thrushes reveals seeds and nuts of fruits that help make up the birds diet. The red cedar high on the canyon bank, the soapberry tree at the head of a tributary canyon or on a hillside above other trees, the solitary grape vine or sand plum in a grassy valley far removed from others of its kind, the skunk-bush (*Rhus canadensis var. trilobata*) perched on the brow of a gypsum-capped butte, the Missouri currant among the rocks on the rough side of a glass mountain, the lone hackberry in a prairie draw, the rock-grape growing in a cleft in a sandstone or granite ledge, are monuments to the services of birds as distributors of plants.

The writer has been much interested in the relation of the wild turkey to the distribution of the black-jack (*Quercus marilandica*) *and* Texas oak (*Q. undulata*). In years when these oaks bear fruit, their acorns have supplied a large proportion of the food of the wild turkeys in the vicinity, and the forests of the former species (black-jack oak) have been most favorable places for the hunter of these birds in winter. Examination of their crops in winter reveals surprisingly large numbers of acorns, often more than a hundred being found in a single bird.

The turkey is a ground-living bird and often travels in flocks for several miles on foot, passing frequently across divides between valleys. Until 20 or 25 years ago this bird was abundant in the semi-timbered and prairie regions of Oklahoma and Texas. The accidental death of one of them often resulted in leaving dozens or scores of acorns on the ground miles from oak trees. Some of these acorns must have been in condition for germination and grown into trees, and the oaks' range was thus extended. In the sandhill region along the north side of Cimarron River in Woods County the black-jack oak reaches its northwestern limit in the State. A similar region along the North Canadian has this tree reaching its last station 30 or 40 miles farther southwestward. Along the borders of the wooded regions in these sections and especially just at the western edge and often from a half to two miles beyond one finds places where numerous small oaks grow very closely together over a few square rods of area showing by their cross-sections about the same age. One finds no such clusters of quite young trees, nor does one find the large oaks in the woods conspicuously clustered. The explanation seems to be that the cluster of young oaks is from acorns left where a coyote, wild-cat, or eagle destroyed a turkey. Most of the trees in the clusters that have been formed for centuries have disappeared in the struggle for existence. and the cluster as such is no longer evident. There are no new outlying clusters now appearing because. it is believed, there are no longer wild turkeys in these regions.

PLANT FAMILIES IN OKLAHOMA.

The following pages give a summarized discussion of the plant life of Oklahoma. The summary is by families. and under each family name, the more common representatives are given, also general statements in regard to habitat, character of growth, distribution, and importance. In some cases where several species are known, the number is indicated by the figure (7) within the parenthesis directly following the name.

FERNS AND AILLIES (PTERIDOPHYTA.)

FERN FAMILY—(*Polypodiaceae*).—Including a large number of ferns, among which are the scaly, beach, powdery, maidenhair, bracken and lip, lady, walking, christmas, shield, woods, evergreen, wood bladder. and sensitive ferns, also several varieties of the royal fern family, adder's tongues, water ferns, the horsetail or scouring rush family, and quillworts.

SEED-BEARING PLANTS—FLOWERING PLANTS (SPERMATOPHYTA).

GYMNOSPERMAE.

PINE FAMILY—(*Pinaceae*).—Includes the pines, cedars (3), juniper, and water cypresses (in swamps in southeastern corner of the State).

ANGIOSPERMAE.

CATTAIL FAMILY—(*Typhaceae*).—The broad-leaved cattail is found in wet places throughout the State, while the narrow leaved or salt plains cattail is found only in wet places in the northwestern part of the State about the salt plains.

BUR-REED FAMILY—(*Sparganiaceae*).—Includes the bur-reeds found in moist or wet places in the eastern half of the State.

POND-WEED FAMILY—(*Naiadoceae*).—Includes the pond-weeds and ditch grasses, water-plantin family (*Alis maceae*). This family includes the arrowheads (*Sagittaria*) (9), the burr-heads (*Echinodorus*), and water-plantins(*Alisma*).

GRASS FAMILY—(*Gramineae.*)—This family includes a very large number of grasses, both wild and cultivated, including the Johnson grass, foxtail, reed grass, blue stems, wild oats, and many others.

SEDGE FAMILY—(*Cyperaceae*).—Includes the cypresses, found in wet sandy soils over most of the State, nut grasses, spike rushes (36), bullrushes (9), umbrella grasses, dwarf sedges, beak-rushes, nut-rushes, and sedges, of which there are a large number.

ARUM FAMILY—(*Araceae*).—This family includes the Indian turnip, or Jack-in-the-pulpit, found in moist woods in the eastern part of the State. The green dragon or dragon root is found in moist woods over the State, except the west and northwest part; and the sweet flag or calamus-root is found in the eastern part of the State.

DUCK WEED FAMILY—(*Lemnaceae*).—This family includes several species of small green plants, floating in large numbers on quiet water, found to some extent over the State, but chiefly in the eastern half.

YELLOW-EYED GRASS FAMILY—(*Xyridaceae*).—Includes only one genus found in the State. This is the slender yellow-eyed grass in the eastern part of the State.

SPIDERWORT FAMILY—(*Commelinaceae*).—Herbs with jointed round stems, mostly branched, including the spiderworts and day-flowers.

PICKEREL WEED FAMILY—(*Pontederiaceae*).—Including the picarelle, wood and mud plantins. The plants of this family grow in the central-eastern part of the State.

RUSH FAMILY—(*Juncaceae*).—Includes the rushes (20).

LILY FAMILY—(*Liliaceae*).—This family includes the bunch flower, false helebore, wild onions (including the garlics), and Oklahoma lily—found on prairies over the entire State, except part of northeast corner, lilies, dog-tooth violet, bellworts, hyacinths, star flower, yuccas (soap root), asparagus, false Solomon's Seal, Solomon's Seal, lily of the valley, wake robin (*Trillium*), and Green briars (7).

YAM FAMILY—(*Dioscoreaceae*).—Wild yam root (Colic root).

AMARYLLIS FAMILY—(*Amaryllidaceae*).—Yellow star-grasses.

IRIS FAMILY—(*Iridaceae*).—Irises, blue flags, and blue-eyed grasses.

ORCHARD FAMILY—(*Orchidaceae*).—This family includes the mocassin flower, the lady's slippers and showy orchis, and several other species.

LIZARD-TAIL FAMILY—(*Saururaceae*).—Lizard-tail in swamps and along pond margins in eastern part of State.

WILLOW FAMILY—(*Salicaceae*).—Including the willows of which there are at least 6 species and the poplars, including the silver-leaved or white poplar and the cottonwoods (2).

WALNUT FAMILY—(*Juglandaceae*).—The walnuts (3) and hickories (10).

BIRCH FAMILY—(*Betulaceae*).—Including the hazel, iron wood, hornbean, birches, and alders.

OAK FAMILY—(*Cupuliferae*).—Including the beech, chestnuts (2), and oaks (17).

NETTLE FAMILY—(*Urticaceae*).—Including the elms (3), hackberries (2), Bois d'Arc (Osage orange), mulberries, woodnettles, stinging nettles, and hops.

SANDAL-WOOD FAMILY—(*Santalaceae*).—Mistletoe. The toad-flaxes, partly as root parasites on trees and shrubs.

DUTCHMAN'S-PIPE FAMILY—(*Aristolochia macrophylla*).—

JOINT WEED FAMILY OR BUCKWHEAT FAMILY—(*Polygonaceae*).—Includes the gray-weeds, docks and sorrels, and joint weeds.

GOOSE FOOT FAMILY—(*Chenopodiaceae*).—Including the sand tumble weed, small cypress, lamb's quarters, mealy goosefoot, oak-leaved goosefoot, dwarf lamb's quarters, Russian thistle, Russian lamb's quarters, and several others; white sage (winter-foot), bug-seed, Jerusalem oak, Mexican tea.

AMARANTH FAMILY—(*Amaranthaceae*).—Includes Amaranths pig-weeds, tumble weeds, western water hemp, and blood-leaf (*Juda's* bush).

POKE-WEED FAMILY — (*Phytolacaceae*). — The poke-weeds (poker-root), common in wet and moist places throughout the State, except the Panhandle counties.

FOUR O'CLOCK FAMILY—(*Nyctaginaceae*).—Including several species of the four o'clock, generally widely distributed.

CARPET WEED FAMILY—(*Aizoaceae*).—Western sea purslane and carpet weeds.

PINK FAMILY—(*Caryophyllaceae*).—The pearl worts, sand worts, chickweeds, corn cockle (corn rose), catchfly, fire pink, starry campion, and bouncing bet.

PURSLANE FAMILY—(*Portulacaceae*).—Spring beauties, common throughout the State, fairy flower, talinums, purslanes, and rose moss.

HORNWORT FAMILY—(*Ceratophyllaceae*).—Hornweeds or hornworts, common in ponds and slow streams in the eastern part of the State.

WATER LILY FAMILY—(*Nymphaeaceae*).—Includes the cow lily (spatterdock), water lilies, American lotus (Chinquapin, water yuankapin), and water target.

CROWFOOT FAMILY—(*Ranunculaceae*).—Including the butter cups (crows-foot), meadow rues, anemone, wild clematis, leather flowers, columbine (rock-bells), lark-spurs, and baneberry.

MAGNOLIA FAMILY—(*Magnoliaceae*).—Magnolia, includes several species, only one of which is native to the State. This is the ***magnolia*** *accuminata* (Cucumber tree).

CUSTARD APPLE FAMILY—(*Anonaceae*).—Pawpaws, (*Asimina triloba*) in wooded areas in the northeastern corner of the State.

MOON SEED FAMILY—(*Menispermaceae*).—Includes the moonseeds and cupseeds. These plants grow along streams, and are widely distributed, except are not found in the western part of the State.

BARBERRY FAMILY—(*Berberidaceae*).—This family includes the may-apple or mandrake. This is found in rich woods in the eastern part of the State.

LAUREL FAMILY—(*Lauraceae*).—Includes the sassafras (ague-tree) and spiced bush. The plants of this family are limited to the eastern part of the State.

POPPY FAMILY—(*Papaveraceae*).—Includes the blood-root, found in rich woods in the eastern part of the State, and the prickly poppies on prairies and sandy soils, widely distributed over the State.

FUMITORY FAMILY—(*Fumariaceae*).—Includes the corydalis, of which there are several varities found chiefly in the eastern half of the State.

MUSTARD FAMILY—(*Cruciferae*).—Includes the whitlow grasses, velvet-flowers, bladder-pods, pepper-grasses (including the tongue grass, penny-cress), shepherd's purse, false flax, horseradish, mustards, turnip, yellow phlox, water-cresses, purple rocket, bitter-cresses, and rock-cresses.

CAPER FAMILY—(*Capparidaceae*).—Clammy-weeds and spider flower.

ORPINE FAMILY—(*Crassulaceae*).—Includes the stonecrop, live-for-ever and rock-moss.

SAXIFRAGE FAMILY—(*Saxifragaceae*).—Texas saxifrage, alum roots, mock-orange, wild hydrangea, Virgina willow, Missouri currant (buffalo-currant).

WITCH-HAZEL FAMILY—(*Hamamelidaceae*).—The witch-hazels, sweet gum (star leaved gum, red gum, bilsted), in woods in eastern and southeastern part of the State, sycamore (buttonball tree, buttonwood plane tree), along streams. This last known tree is found along the streams in the eastern half of the State, and westward to the Chickaskia River, along the north side.

ROSE FAMILY—(*Rosaceae*).—American ipecac, in the extreme eastern edge of the State; apple trees including the western crabapple, on river bottoms in the northeastern part of the State; service berry (shadbush) over the eastern edge of the State, westward to the Arkansas River in the northern part.

HAWS OR THORN FAMILY—(*Crataegus*).—Thorns (11). Wild strawberries, cinquefoils, avens, small-leaved nut, mahogany (on sandstone buttes in Cimarron County), blackberries, raspberries, dewberries, agrominy, wild roses, (6), wild plums, wild berries (10).

PEA FAMILY—(*Legiminosae*).—This family includes the sensitive briar found on rough hill sides and grassy slopes throughout the State, except in the extreme western part; Desmanthus (3), mesquite (on prairies and river valleys in the western third of the State); Kentucky coffee tree (coffee-bean tree), honey locust, blueweed or cycle pod, partridge pea. sensitive plants, bank burr, redbud, Judas tree, wild indigo, and false indigo, rattle boxes, Nebraska bluepine (western Panhandle counties), clovers (trifolium), sweet clovers, prairie bird's foot, trefoil. snakeroot, Indian or prairie turnip, also called bread-root, bead plant, or devil's shoestring, river locust or false indigo, wild sweet pea, western indigo plant, peatree, wisteria, ground plums, tick-trefoil (15), bush-clovers (12), pencil flower, vetches (8), wild peas, ground-nut, wild bean, hog peanut, milk peas.

FLAX FAMILY—(*Linaceae*).—Includes the cultivated and wild flaxes (8).

OXALIS FAMILY—(*Oxalidaceae*).—This family includes the oxalis or wood sorrels. All of the forms are found throughout the State, but are most abundant in the central and eastern part.

GERANIUM FAMILY—(*Geraniaceae*).—Crane's bill geraniums, in waste places and lawns, over most of the State, but chiefly in the eastern part.

CALTROP FAMILY—(*Zygophyllaceae*).—Herbs having prostrate much branched stems, including the coltrap burr, or Mexican sand burr found in the northwestern part of the State; and the greater caltrop found throughout the prairie parts of the State.

RUE FAMILY—(*Rutaceae*).—Includes the prickly ash or toothache tree, found in the eastern and southern parts of the State; and the hop tree (*ptelea trifoliata*), found in open woods and rocky banks throughout the State.

MILKWORT FAMILY—(*Polygalaceae*).—Includes 5 species of the milkwort, widely distributed throughout the State.

SPURGE FAMILY—(*Euphorbiaceae*).—This family includes several plants, among which are the spurge nettles (tread-softly), the croton weeds (goat weed), the three-seated mercury, queen's delight, and the spurges (23).

SUMAC FAMILY—(*Anacardriaceae*).—Includes the sumacs, poison ivy and American smoke-tree (eastern part of the State).

HOLLY FAMILY—(*Ilicaceae*).—Includes the hollys of which 2 species are found in Oklahoma, the American white or Christmas holly, and the swamp holly, found in swamps and thickets in the eastern part of the State.

STAFF TREE FAMILY—(*Celastraceae*).—Includes the wahoos (burning bush) and bittersweets.

BLADDERNUT FAMILY—(*Staphyleaceae*).—The true bladdernut is represented by only one species in our State, the American bladdernut found in woods and thickets in the northeast corner of the State.

MAPLE FAMILY—(*Aceraceae*).—Several species found growing chiefly in the eastern part of the State, also many varieties in cultivation. (See list of trees and shrubs following).

SOAPBERRY FAMILY—(*Sapindaceae*).—This family is represented by the chinaberry or soap berry tree, and three or four species of the buckeye.

FOR-GET-ME-NOT FAMILY—(*Balsaminaceae*).—This family is represented only by the spotted or wild touch-me-not, sometimes called silver leaf, found in moist places in the eastern part of the State.

BUCKTHORN FAMILY—(*Rhamnaceae*).—This family includes chapparel (condilia), supple jack (rattan vine), Carolina buckhorn, and New Jersey Tea or redroot.

GRAPE FAMILY—(*Vitaceae*).—This family includes the Virginia creeper, which is common throughout the State; the false grapes, pepper vine, and several species of wild grapes.

LINDEN FAMILY—(*Tiliaceae*).—This family includes the basswood or linden tree of which there is but one species growing native in the State.

MALLOW FAMILY—(*Malvaceae*).—Includes the Indian mallow, false mallow, running mallow, poppy mallows (6), and rose mallows (3).

SAINT JOHN'S-WORT FAMILY—(*Hypericaceae*).—This family includes St. Andrews' cross and the St. John's-wort of which there are several species, found chiefly in the eastern part of the State.

ROCK-ROSE FAMILY—(*Cistaceae*).—This family includes the frost weeds and the pin weeds, found growing in dry, sandy places in the eastern two-thirds of the State, and also in the vicinty of the Wichita and Arbuckle mountains.

VIOLET FAMILY—(*Violaceae*).—There are about 20 species of violets known in the State. Some of these are widely distributed, but are chiefly found in the eastern part of the State.

PASSION FLOWER FAMILY—(*Passifloraceae*).—This family is represented by 2 species found in the eastern part of the State.

LOASA FAMILY—(*Loasaceae*).—Consisting of small, much branched herbs with rough surfaces and with barbed stinging hairs, found on sandy hill sides and prairies throughout the State.

CACTUS FAMILY—(*Cactaceae*).—This family is represented by the hedgehog, pin cushion, cacti, and the prickly pears.

LOOSESTRIFE FAMILY—(*Lythraceae*).—This family includes the water purslane, tooth cups, loosestrifes and wax-weeds.

MEADOW BEAUTY FAMILY—(*Melastomaceae*).—Includes the meadow beauties found growing in sandy, swampy places in the eastern part of the State.

EVENING PRIMROSE FAMILY—(*Onagraceae*).—Includes various willow-herbs, the evening primroses (19), gaura, and enchanter's night shade.

WATER MILLFOIL FAMILY—(*Haloragidaceae*).—These are aquatic herbs, including the water millfoil and the mermaid weeds.

GINSENG FAMILY—(*Araliaceae*).—This family is represented in our State only by the common ginseng (*panax quinquefolia*), found in rich woods in the eastern part of the State.

PARSNIP FAMILY—(*Umbelliferae*).—This family is represented in our State by several species of the snakeroot, pennyworts, chervil, sweet cicely, sand parsley, cowbane, hedge parsley.

DOGWOOD FAMILY—(*Cornaceae*).—The dogwoods, small trees or shrubs, represented in this State by 4 species and the tupelos, represented by tupelo gum, and the sour or black gum.

LOGANIA FAMILY—(*Loganiaceae*).—A family represented by only 2 species in our State, so far as known.

GENTIAN FAMILY—(*Gentianaceae*).—This family includes the rose-pinks and centaurys.

DOGBANE FAMILY—(*Apocynaceae*).—Includes amsonia, dogbane and Indian hemp.

MILKWEED FAMILY—(*Asclepiadaceae*).—This family includes the milkweeds, of which there are at least 20 species, the sand vine, and baldwin's anglepods.

MORNING-GLORY FAMILY—(*Convolvulaceae*).—This family includes the morning-glories, of which there are 10 or 12 species, widely distributed over the State; the bindweeds and dodders.

PHLOX FAMILY—(*Polemoniaceae*).—The family includes the phloxes and gilias.

WATERLEAF FAMILY—(*Hydrophyllaceae*).—Includes phacelia and nama.

BORAGE FAMILY—(*Boraginaceae*).—This family includes the heliotropes (4), wild comfrey, stickseeds, for-get-me-nots, scorpion grasses. puccoons, and western false gromwell.

VERVAIN FAMILY—(*Verbenaceae*).—Includes the verbenas or vervains, of which there are 11 species; the lippia (fogfruit); and the French mulberry, a fruit with a blue, berry-like group, with 4 nutlets, but does not belong to the mulberry family.

HEATH FAMILY—(*Ericaceae*).—This family includes the Indian pipe or ghost flower, the azeleas, male berry, and the huckleberries. All the plants of this group growing are found in the eastern and southeastern parts of the State.

PRIMROSE FAMILY—(*Primulaceae*).—This family includes the water pimpernells, loosestrifes, chaffweeds, shooting star (American cowslip), Indian chief, rooster head. The plants of this group occur in moist soils and along streams in the southern and southeastern part of the State.

SAPODILLA FAMILY—(*Sapotaceae*).—This family is represented in our range by only one species. chittim-wood, the woody buckthorn (Bumelia launginosa). This species occurs in open woods throughout the State. Southern buckthorn occurs in the Arbuckle Mountains (*Bumelia lyciodes*Q.

EBONY FAMILY—(*Ebenaceae*).—This family is represented by one species in our State, the common persimmon (*Diospyros virginia*). This species occurs as a shrub or small tree in creek valleys and draws throughout the State, except in the Panhandle counties.

STORAX FAMILY—(*Slyracaceae*).—This family is represented by the silverbell or snowdrop tree. It occurs in the southeastern part of the State.

OLIVE FAMILY—(*Oleaceae*).—This family includes the ashes of which there are at least 3 species in the State; the swamp privets; and the fringe-tree or old man's beard.

MINT FAMILY—(*Labiatae*).—This family includes a large number of plants which are the fermanders (woodsage), pennyroyal, skullcaps (6), common or white horehound, hyssop, catnip or catmint, ground ivy, carpenter weed or heal-all, dragonhead or lion's heart, henbit, common motherwort, hedgenettle, sage, horsemint, woodmint, pennyroyal (3). low calamint, mountainmint, water horehounds, spearmint and peppermint.

POTATOE FAMILY—(*Solanaceae*).—This family includes the night shades (8), among which are the various night shades, named chiefly from the shape of the leaf; the horsenettle; and buffalo burr (bull-nettle, Santa Fe thistle, sand burr); the ground cherries (31); and the jimson weeds.

FIGWORT FAMILY—(*Scrophulariaceae*).—This family includes the mullins (2), found in the eastern and northeastern parts of the State, the toad flaxes (2) (butter and eggs, blue toad-flax), the figworts, beard-tongues, monkey flowers, hyssops, mullin (fox-glove), gerardia (9), blue-hearts, painted cup, and Indian paint brush.

BLADDERWORT FAMILY—(*Lentibulariaceae*).—This family includes certain low, delicate herbs living in water or moist soils. The family is represented by 4 or 5 species occuring in the eastern half of the State, and in the vicinity of the Wichita Mountains.

BROOM-RAPE FAMILY—(*Orobranchaceae*).—This family is represented by 2 species—the Louisiana broom-rape, found in sand soils in the western end of the State, and in the Panhandle counties, and the one flowered broom-rape or cancer root, growing parastic on the roots of several species of herbaceous plants in the eastern part of the State.

CATALPA FAMILY—(*Bignoniaceae*).—The family is represented in Oklahoma by the trumpet creeper vine (*tecomma radiacans*); and the western catalpa,(.hardy catalpa, cigar tree, catawba tree) (*catalpa* *speciosa*), and the southern catalpa or Indian bean (*catalpa bignoniydes*). Both of these catalpas are planted for shade and the former one especially being extensively grown.

MARTYNIA FAMILY—(*Martyniaceae*).—This family is represented in the western part of the State by a single genus which includes one species so far as known—devil's claw or unicorn plant.

ACANTHUS FAMILY—(*Acanthaceae*).—This family includes the water-willows (3) and the ruella.

LOPSEED FAMILY—(*Phrymaceae*).—The family is represented by a single species of lopseed found in woods and thickets in the northern and northeastern parts of the State.

PLAINTAIN FAMILY—(*Plantaginaceae*).—This family includes the common plaintains (12), widely distributed over the State.

MADDER FAMILY—(*Rubiaceae*).—This family includes several species of plants within the State, among which are the bed-straws, wild liquorice, the button weeds, partridge berry or tern berry, butterbush or globe flower and the bluets.

HONEY-SUCKLE FAMILY—(*Caprifoliaceae*).—Includes the honeysuckles, found chiefly in the eastern and southern parts of the State, the coral berry or buck-bush (*symphoricarpos symphoricarpos*), in woods along streams throughout the State, except the extreme northwestern and Panhandle counties, black haws (2), and the common elder, found along streams over the entire State, except in the Panhandle counties.

VALERIAN FAMILY—(*Valerianaceae*).—This group includes 2 or 3 species among which are the cornsalids found in the eastern and southern parts of the State.

GOURD FAMILY—(*Cucurbitaceae*).—This family includes the wild gourds, squashes, and pumpkins.

THE CAMPANULA FAMILY—(*Campanulaceae*).—Herbs with milky sap, among which are the venus-looking glass, and bell flowers.

LOBELIA FAMILY—(*Lobeliaceae*).—Includes lobelias (6).

THISTLE FAMILY—(*Compositae*).—This family includes a large number of our herbs and a few of the shrubs. Among these plants are the iron weeds (veronia) (7), bonesets or thoroughworts (10) (*eupatorium*) elephant's foot (*elephantopus*), blazing stars (5), rosinweeds or gumplants (3), broom weeds, kindling weed or august flower, golden asters (4), goldenrods (21), sand daisies, daisies, asters (20), fleabanes (11), willow baccharis (in river valleys in the western half of the State), rabbit tobacco, marshfleabanes, cat's-foot, pearly everlasting, white balsam, sweet life everlasting, purple cudweed, leaf-cups, rosin-weeds (5), ferverfew, ragweeds (5), cockle-burs (3), prairie zinnia, false sunflowers, cone-flowers (14), column flowers, sunflowers (20), coreopsis (7), beggar-ticks or sticktights, including the Spanish needles, sneeze weeds, yarrows, dog-fennel (may-weed), feted marigold, ox-eyed daisy, sage brushes (11), Indian Plantains, common groundsel, butterweed, ragworts, squawweed, common burdock, thistles (5), American starr thistle, chickory, dwarf dandelion (3), false dandelion, common dandelion, sow thistles, including the spring sow thistle and rabbit lettuce, wild lettuce (8), rattlesnake root, white lettuce, and hawkweeds (3).

TREES AND SHRUBS.

Far back in geologic history we find the records of tree growth.

Our coal beds are the products of abundant growth of vegetation, consisting in a large part of trees, many of which reached large proportions. Fossil leaves, plants, and twigs in the shales and sandstones, and the silicified trunks of trees commonly found bear out the extensive growth of trees in times past.

Within recent times the greater part of the land surface of the earth has been covered with forest growth. At the present time trees are among the most conspicuous objects of nature. It has been estimated that the aggregate original area of the forests of North America was about 850 million acres. This original area has been reduced until not more than 550 million acres remain, and a large percentage of this is not to be considered in the area of the economic timbered region.

A tree is usually defined as a plant with a single trunk of woody structure that does not branch for some distance above the ground. Woody plants that branch directly above the soil, although they grow to a height of 20 feet or more, are called shrubs or bushes. Certain shrubs may be made to grow treelike, and some plants which are shrubs in the northern states grow as trees of considerable size farther south.

A tree consists of three parts; first, the root; second, the branch or stem; third, the crown. The root extends into the ground from a few inches to several feet, according to the variety of tree, character of soil, and the moisture conditions. The trunk or stem supports the crown and supplies it with mineral food and water from the roots. The crown consists of a network of branches, buds, and leaves. The most important processes in the growth, reproduction and nourishment of the tree, take place in the crown.

Trees and shrubs as they stand together on some large area whose principal crop is trees and shrubs constitutes a forest. However, a forest is far more than a collection of trees. It has a population of animals and plants peculiar to itself, a soil largely of its own making, and climatic conditions differing from those in the open country. The forest prevents floods, influences rainfall, supplies fuel, timber, and food.

But with all the good that the forest has been to man its real value has not been considered and it has been recklessly used and ruthlessly destroyed.

The United States is divided into several forest regions. A single unbroken forest belt—the spruce forest of Canada, extends across North America. *(1) A part of this belt extends within the borders of the United

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(1) Bowman, Isaac, Forest Physiography, p. 123.

States in the region about the Great Lakes. This region has the typical growth of black and white spruce, poplar, canoe birch, aspen, and tamarack.

To the southward from the south limit of this spruce forest are marked forest regions extending in a north-south line. These are the Atlantic forest, the Pacific forest, the Rocky Mountain forest, and the forested regions of the Great Basin. The Great Plains region is forestless but not treeless.

Oklahoma is in part in the forest region of the Great Basin and part in the region of the Great Plains. The east one-third of the State lies chiefly in the timbered belt. The southeastern part of the State has a forest growth, which places it in the southern forest belt which is chiefly characterized by the long leaf, short leaf, loblolly, and slash pine. In the northeastern part of the State east of Grand River and north of the Arkansas is found a tree growth very characteristic of a hardwood forest of the central Mississippi valley. The remainder of the principal timbered region of the State lies within the Sandstone Hills region, except the area in the Arbuckle Mountain and the Cretaceous plains along Red River.

A strip 75 miles wide clear across the east side of the State is covered with heavy timber. The northern part of the strip is hard wood. South of Arkansas River it is chiefly pine, hickory, and oak. There are millions and millions of feet of valuable timber. The pine is of the yellow variety. The hardwood is oak, hickory, walnut, elm, and maple. In the southeastern part of the State pine timber is of much more value than the land on which it stands. One lumber company, it is said, owns enough timber to keep its mills running 20 years if they cut 100,000 feet every day.

In the western half of the State trees are found usually only along the streams or on the sandhills. The level uplands are grass covered. Cottonwood, elm, hackberry, chinaberry, walnut, willow, dogwood, redbud, soapberry, box elder and mulberry are the chief kinds found. On the flat prairies and along some of the streams in the western part is found the thorny mesquite. Blackjack, barren, post oak, hackberry, hickory, and sumac grow on the sand hills. On the high plains in the extreme western part of the State there are very few trees even along the streams, but even here an occasional low elm or dwarf cottonwood or willow may be found. One of the problems which confronts the citizens is to discover what trees may be transplanted and grown in the treeless part of the State. The inhabitants desire shade trees and it is important that trees be secured which will meet the conditions. Difficulty will often be experienced in getting trees started in this region, but many efforts will meet with success.

The black locust, soft maple or silver maple, box elder or ash leaved maple, the green ash, mulberry, and catalpa are being most widely planted for shade in our cities. Cottonwood may also be added to the list. The chief reason for selecting most of these trees is that they are quick growing. The locust if used will have to be safeguarded against the locust borers which have wrought such great havoc in other states; the catalpa against the catalpa sphinx. The cottonwood, while a very rapid grower, has its faults. It sheds leaves continually through the summer and becomes bare in early fall, and the roots find their way into wells and sewers and do much damage. In many eastern cities ordinances have been passed requiring all cottonwoods within 100 feet of sewers to be cut. The walnut, red bud and oaks may also be added to the list for shade. In Oklahoma City many oaks and cottonwoods of the original forest still stand for shade. Among imported trees suitable for street and lawn planting are the dwarf catalpa, linden, tree of Heaven, Paulounia, and Koelreuteria paniculata, a native of China. Fruit trees may also be used for shade even for planting along streets and roadways. People will soon learn to respect the trees and they will not be abused in securing the fruit.

Trees have two distinct modes of branching—one has a central stem running the entire length of the tree as in the hickory or pine. This is called the excurrent growth. In the second class the main stem is soon lost in the branches as in the walnut or catalpa. This is known as delinquescent growth. Two kinds of roots are found on trees—those having a tap root as in the hickory and oaks. These trees are difficult to transplant. Those having multiple roots in which the roots are numerous and extend outward from the base, as in the maples and elms. Such trees are easily transplanted.

Willows and poplars may be started by branches placed in the ground. Most trees are best grown from the seed. Trees best for transplanting are those not more than two years old.

A LIST OF TREES AND SHRUBS OF OKLHAMOA.

Trees and shrubs are plants which belong to the sub-kingdom—SPERMATOPHYTA—the seed-bearing plants. The plants of this division belong to two classes—the GYMNOSPERMAE, plants with naked seed; and ANGIOSPERMAE, plants with protected seeds.

CLASS I. GYMNOSPERMAE.

Naked Seeds.

The Gymnosperms are an ancient group of plants. They are found among the fossils of the Silurian age, and are most numerous in Triassic time. They are now represented by about 450 species of trees and shrubs. They are flowering plants in which the ovules, or seeds, are not inclosed in an ovary, but are borne naked upon an open scale. This scale is a modified leaf. The plants have a resinous juice, and chiefly parallel-veined, needle-shaped, or scale-like evergreen leaves. By far the larger number of the Gymnosperms are Coniferous (Pinacae or Coniferae including some shrubs) or cone-bearing trees, the fruit being called a cone because of its form. This family of the class is the only one represented in our area.

PINE FAMILY. PINACEAE.

Pines. Conifers.
Pinaceae. Coniferae.

The trees belonging to this family are commonly known as Evergreens, because with the exception of the Larch and the Bald Cypress they do not shed their leaves during the winter.

PINES. GENUS PINUS.

Loblolly pine. (Old Field pine. Rosemary pine).
Pinus Taedea.

Yellow pine. (Short-leaf pine. North Carolina pine, Spruce pine.)
Pinus echinata.

Southern or Bald cypress. (Deciduous cypress.)
Taxodium distichum.

Red cedar. (Common cedar. Juniper.)
Juniperus Virginiana.

Juniper. (Ground cedar.)
Juniperus communis.

Arbor vitae. (White cedar.)
Thuja occidentalis.

CLASS II. ANGIOSPERMAE.

Enclosed Seeds.

MAGNOLIA FAMILY. MAGNOLIACEAE.

Found in the extreme eastern and southeastern part of the State.

TULIP TREE. GENUS LIRIODENDRON.

Tulip tree. (Yellow poplar. Tulip poplar.)
Liriodendron tulipifera.

CUSTARD APPLE FAMILY. ANONACEAE.

PAPAWS. GENUS ASIMINA.

Common papaw. (Found only in the eastern part of the State)
Asimina triloba.

TAMARISK FAMILY. TAMARISCINEAE.

The *Tamarisks* are sub-evergreen, shrubs or small trees, with very small pinkish flowers, in spike-like clusters, or thickly grouped along the slender drooping branches. The leaves are very small and scale-like. There are several species in cultivation, and numerous names have been applied by nursery men. Many of the members of this family are found growing escaped from cultivation about old building places. Some of the varieties are now being used to considerable extent for hedges about lawns and gardens.

MALLOW FAMILY. MALVACEAE.

The *Hibiscus* or *Rose Mallows* comprise a large family of mainly herbaceous plants with large holly-hock-like flowers. There is but one cultivated species in this region which has woody structure and tree-like appearance. This is the *Shrubby Althea* or *Hibiscus Syriacus* commonly called *Tree Hibiscus* or *Rose of Sharon.* This was originally introduced from Syria. There are many varieties with single or double flowers of many colors,—white, pink, red, purple, and variegated. A large number of these have been planted for ornament over the State and some have been observed which had reached a height of 15 to 20 feet.

LINDEN FAMILY. TILIACEAE.

LINDENS OR BASSWOOD. GENUS TILIA.

Basswood.. (Whitewood. Linden. Lime Tree.)
Tilia Americana.

The range of the basswood extends through the eastern half of Oklahoma and though it is not abundant, is found scattering here and there in the areas of good soil. It is also in cultivation in the State. Another tree, probably a variety of the above, is found in cultivation. This is *Tilia pubescens,* small leave basswood. Several introduced species and nursery varieties are much valued for their dense foliage, odd-shaped leaves, and slender branches.

RUE FAMILY. RUTACEAE.

PRICKLY ASHES. GENUS XANTHOXYLUM.

Prickly ash. (Toothache tree.)
Xanthoxylum Clava-Hercules.

WAFER ASHES. GENUS PTELEA.

Wafer ash. (Hop-tree. Shrubby trefoil.)
Ptelea trifoliata.

This shrub, often growing with the true shape of a tree, never attains a height of more than a few feet (6-10). The fruit resembles that of the elm but is larger. It is known to occur from the east side to as far west as Alva in Woods County.

CORK TREE. GENUS PHELLODENDRON.

Chinese cork tree.
Phellodendron Amurense.

An introduced tree with compound leaves resembling those of the Tree of Heaven. The cork tree is being planted in some of our city parks, and grows fairly well.

MELIA FAMILY. MELIACEAE.

CHINA TREE. GENUS MELIA.

China-tree. (China-Berry tree. Pride of India.)
Melia Azedarach.

QUASSIA FAMILY. SIMARUBACEAE.

TREE OF HEAVEN. GENUS AILANTHUS.

Tree of Heaven. (Paradise tree. Chinese sumac.)
Ailanthus glandulosus.

This tree was originally introduced from China and Japan, but it is now widely cultivated and naturalized. It is found growing wild in many places, having escaped from cultivation. It is a very rapid-growing tree and hardy throughout. At all times of the year it has a good appearance and is well adapted for shade and ornamental purposes.

HOLLY FAMILY. ILICINAE.

HOLLIES. GENUS ILEX.

American holly. (Christmas holly.) Swamp holly. (Deciduous holly.)
Ilex apaca. *Ilex decidua.*

Ink berry.
Ilex glabra.

STAFF-TREE FAMILY. CELASTRACEAE.

WAHOO. GENUS EUONYMUS.

Wahoo. (Burning Bush. Spindle tree.)
Euonymus atropurpureus.

BITTER SWEET. GENUS CELASTRUS.

Bitter sweet. (Waxwork.)
Celastrus scandens.

SOAPBERRY FAMILY. SAPINDACEAE.

SOAPBERRY. GENUS SAPINDUS.

Soapberry (c). (Western soapberry. Wild China tree.)
Sapindus Drummondi.

A small tree common throughout the State, except extreme northwest. Rare in some localities. Easily distinguished by its clusters of fruit remaining more or less shriveled on the tree until spring. The largest tree observed was in the Grand River Valley and was 10 inches in diameter and more than 30 feet high. Often a large number of the trees are found growing together.

HORSE-CHESTNUT FAMILY. HIPPOCASTANACEAE.

HORSE CHESTNUTS. GENUS AESCULUS.

Common horse chestnut.
Aesculus Hippocastanum.

Yellow buckeye. (Sweet buckeye.)
Aesculus octandra.

Ohio buckeye. (Sweet buckeye. Fetid buckeye.)
Aesculus glabra.

GENUS KOELREUTERIA.

Koelreuteria paniculata.

MAPLE FAMILY. ACERACEAE.

MAPLES. GENUS ACER.

Silver maple. (Soft maple. White maple. River maple.)
Acer saccharinum.

Red, scarlet, or water maple. (Swamp maple.)
Acer rubrum.

Hard maple. (Sugar or rock maple. Sugar-tree.)
Acer saccharum.

Black maple. (Sugar maple.)
Acer nigrum.

Box Elder. (Ash-leaved maple.)
Acer negundo.

The NORWAY MAPLE, *acer platanoides,* and CUT-LEAVED JAPANESE MAPLE, *acer palmatum,* are in cultivation, but so far have not made very successful growth in the localities where planted.

BLADDER-NUT FAMILY. STARPHYLEACEAE.

American Bladder-nut.
Staphylea trifoliata.

CASHEW FAMILY. ANACARDIACEAE.

SUMACHS. GENUS RHUS.

Smooth sumac. (Upland or scarlet sumac.)
Rhus glabra.

Dwarf, black or mountain sumac. (Upland sumac.)
Rhus copallina.

Poison sumac. (Poison dogwood. Poison elder.)
Rhus Venenata.

Cut-leaved sumac.
Rhus lacinata.

Ill scented sumac. (Skunk bush.)
Rhus trilobata.

Fragrant or sweet-scented sumac.
Rhus aromatica.

Poison ivy. (Poison oak. Climath. Three leaf ivy.)
Rhus radicans.

Wild or American smoke tree. (Chittam wood.)
Rhus cotinoides.

PULSE OR PEA FAMILY. LEGUMINOSAE.

LOCUSTS. GENUS ROBINIA.

Common locust. (Yellow locust. Black locust. Silver chain.)
Robinia pseudacacia

REDBUDS. GENUS CERCIS.

Judas tree. (Redbud.)
Cercis canadensis.

Common throughout except far western part of State. Grows as a shrub to small tree, reaches height of 20 feet. Excellent for lawn planting.

COFFEE TREE. GENUS GYMNOCLADUS.

Kentucky coffee tree. (Coffee-nut.)
Gymnocladus Canadensis.

HONEY-LOCUSTS. GENUS GLEDITSCHIA.

Honey locust.
Gleditschia triacanthos.

Water locust.
Gleditschia aquatica.

ROSE FAMILY. ROSACEAE.

PEACHES, PLUMS, AND CHERRIES. GENUS PRUNUS.

Common peach.
Prunus Persica.

Nectarine. (Smooth-skinned peach.)
Prunus laevis.

Pigeon cherry. (Pincherry. Bird cherry. Wild red cherry.)
Prunus Pennsylvanica.

Wild black cherry. (Cabinet or river cherry.)
Prunus serolina.

American plum. (Wild plum.)
Prunus Americana.

Wild goose plum. (River plum.)
Prunus hortulana.

Chickasaw plum.
Prunus Augustifolia.

Watson's plum. (Sand plum.)
Prunus Watsoni.

Low plum.
Prunus gracilis.

Choke cherry.
Prunus Virginiana.

Western sand cherry. (Bessy's cherry.)
Prunus Besseyi.

APPLES AND PEARS. GENUS PYRUS.

Common apple
Pyrus malus.

Soulard crab.
Pyrus soulardi.

Prairie crab.
Pyrus isensis.

Common pear.
Pyrus communis.

American or garland crab. (Fragrant crab.)
Pyrus coronaria.

American or small fruited ash.
Pyrus americana.

Elder-leaved or large fruited mountain ash.
Pyrus sambricifolia.

GENUS AMELANCHIER.

June-berry. (Service-berry. Shad bush.)
Ameleanchier Canadensis.

HAWS OR THORNS. GENUS CRATAEGUS.

Green haw.
Crataegus viridis.

Washington thorn.
Crataegus cordata.

Dotted fruited hawthorn.
Crataegus punctata.

GENUS RUBUS.

WITCH HAZEL FAMILY. HAMAMELIDACEAE.

GENUS HAMAMELIS.

Witch hazel.
Hamamelis Virginiana.

Found in central-east side, north of Arkansas River. The largest observed was south of Marble City.

GENUS LIQUIDAMBAR.

Sweet gum. (Bilsted. Red gum.)
Liquidambar styraciflua.

This tree is found in the east side of the State south of Arkansas River. It is abundant along Poteau and Kiamichi rivers and their tributaries. It is a tree worthy of extensive cultivation.

GINSENG FAMILY. ARALIACEAE.

GENUS ARALIA.

Angelica tree. (Hercules club.)
Aralia spinosa.

The range of this tree would include the southeastern corner of the State; however, so far as known it has not been found. It is used for ornamental planting and is worthy of extensive use.

DOGWOOD FAMILY. CORNACEAE.

DOGWOOD OR CORNELS. GENUS CORNUS.

Flowering dogwood.
Cornus florida.

Rough leaf or white fruited dogwood.
Cornus asperifolia.

TUPELOS. GENUS NYSSA.

Pepperidge. (Black or sour gum.)
Nyssa sylvatica.

HONEY-SUCKLE FAMILY. CAPRIFOLIACEAE.

NANNY-BERRIES. GENUS VIBURNUM.

Rusty nanny berry. (Southern nanny berry.)
Viburnum rufidulum.

Small black haw.
Viburnum globosum.

Cranberry tree. (Snow ball or Guelder rose.)
Viburnum opulus.

GENUS SYMPHORICARPOS.

Coral-berry.
Symphoricarpos symphoricarpos.

Wolfberry.
Symphoricarpos occidentalis.

GENUS LONICERA.

Tartarian bush honeysuckle.
Lonicera Tartarica.

Honeysuckle.
Lonicera.

GENUS DIERVILLA.

Bush honeysuckle.
Diervilla diervilla.

GENUS SAMBUCUS.

American elder. (Sweet elder. Elderberry.)
Sambucus Canadensis.

SAPODILLA FAMILY. SAPOTACEAE.

BUMELIAS. GENUS BUMELIA.

Wooly bumelia. (Chittim wood. Buckthorn. Gum elastic.)
Bumelia languinosa, also *Bumelia lycioides.*

BUCKTHORN FAMILY. RHAMNACEAE.

BUCKTHORNS. GENUS RHAMNUS.

Yellow buckthorn. (Indian cherry.)
Rhamnus Caroliniana.

GENUS CEANOTHUS.

New Jersey tea. (Red root.)
Ceanothus Americanus.

EBONY FAMILY. EBENACEAE.

PERSIMMONS. GENUS DIOSPYROS.

Common persimmon.
Diospyros Virginiana.

Japan persimmon. (c).
Diospyros Kaki.

STORAX FAMILY. STYRACACEAE.

SILVER BELL TREES. GENUS MOHRODENDRON.

Silver bell tree. (Snow drop tree.)
Mohrodendron Carolinum.

OLIVE FAMILY. OLEACEAE.

ASHES. GENUS FRAXINUS.

White ash.
Fraxinus Americana.

Swamp ash or water ash.
Fraxinus platycarpa.

Blue ash.
Fraxinus quadrangulata

Green ash.
Fraxinus viridis.

FORESTIERA. GENUS ADELIA.

Adelia. (Forestiera. Swamp privet.)
Adelia acuminata.

PRIVET. GENUS LIGUSTRUM.

Privet. (Prim.)
Ligustrum Vulgari.

SYRINGIA. GENUS SYRINGIA.

Common lilac.
Syringia vulgaris.

Japan lilac.
Syringia Japonica.

GENUS CHIONANTHUS.

Fringe tree.
Chionanthus Virginica.

FIGWORT FAMILY. SCROPHULARIACEAE.

GENUS PAULOWNIA.

Imperial paulownia. (Paulownia tree.)

BIGNONIA FAMILY. BIGNONIACAE.

CATALPAS. GENUS CATALPA.

Indian bean. (Southern catalpa.)
Catalpa bignonioides or *Catalpa catalpa.*
Hardy catalpa. (Western catalpa. Catawba tree.)
Catalpa speciosa.
Japanese catalpas. (c).
Catalpa Kaempferi and *Catalpa Bungei.*

Dwarf forms growing from 5 to 10 feet, umbrella-shaped tops. Grown in cities and parks.

LAUREL FAMILY. LURACEAE.

BAY TREE. GENUS PERSEA.

Red bay.
Persea Borbonia.

SASSAFRAS. GENUS SASSAFRAS.

Sassafras.
Sassafras sassafras or *Sassafras officinale.*

GENUS LINDERA.

Spice bush. (Benjamin bush.)
Lindera Benzoin.

OLEASTER FAMILY. ELAEAGNACEAE.

Several members of the family in cultivation. A specimen of the RUSSIAN OLIVE, or OLEASTER, was observed which was at least 20 feet in height. The DESERT WILLOW, *chilopsis linearis,* from Texas is found in Oklahoma City. The BUFFALO BERRY or RABBIT BERRY has been found by the writer growing along the Canadian in the western part of Cleveland County.

NETTLE FAMILY. URTICACEAE.

ELMS. GENUS ULMUS.

American or white elm.
Ulmus Americana.

Slippery or red elm.
Ulmus fulva or *U. pubescens.*

Wahoo or winged elm.
Ulmus alata.

GENUS PLANERA.

Planer tree. (Water elm.)
Planera aquatica.

HACKBERRIES. GENUS CELTIS.

Sugar berry. (Hackberry.)
Celtis occidentalis.

Hackberry.
Celtis var.

Mississippi hackberry. (Sugar hackberry.)
Celtis Mississippiensis.

OSAGE ORANGE. GENUS MACLURA.

Osage orange. (Bow-wood. Bois d'Arc.)
Toxylon pomiferum, or Maclura aurantiaca.

MULBERRIES. GENUS MORUS.

Red mulberry.
Morus rubra.

White mulberry.
Morus alba.

Both of these mulberries are grown for shade. The largest white mulberry known in the State is in Norman. This tree is a foot in diameter and 50 feet high. The Russian or barren mulberry, extensively grown for shade, is the staminate white mulberry. It is a rapid grower and a good tree to plant.

GENUS BROUSSONETIA.

Paper mulberry.
Broussonetia papyrifera.

French mulberry.
Callicarpa Americana.

A shrub reported as occuring in the northeast corner of the State. Does not belong to the Mulberry family.

PLAN-TREE FAMILY. PLATANACEAE.

GENUS PLATANUS.

Sycamore. (Buttonwood.)
Platanus occidentalis.

Oriental plane. (c).
Platanus orientalis.

WALNUT FAMILY. JUGLANDACEAE.

WALNUTS. GENUS JUGLANS.

Butternut. (White walnut.)
Juglans cinerea.

Black walnut.
Juglans nigra.

HICKORIES. GENUS CARYA OR HICORIA.

Bitternut hickory. (Swamp hickory.)
Hickory minima.

Water hickory. (Swamp hickory.)
Hicoria aquatica.

Big shell bark hickory. (King nut.)
Hicoria ovata or *Carya sulcata.*

Mocker-nut hickory.
Hicoria alba or *Carya tomentosa.*

Pignut hickory.
Hicoria glabra or *Carya porcina.*

Pecans.
Hicoria pecan.

Pale-leaf hickory.
Hicoria villosa.

WILLOW FAMILY. SALICACEAE.

WILLOWS. GENUS SALIX.

Peach or almond-leaf willow. (Western black willow.)
Salix amygdaloides.

Long-stalked willow. (Ward willow.)
Salix longipes.

Black willow.
Salix nigra.

Narrow or long-leaved willow. (Sand-bar willow. Ring willow.)
Salix longifolia or *S. fluviatilis.*

POPLARS. GENUS POPULUS.

White poplar. (Abele tree. Silver-leaf poplar.)

Populus alba.
Cottonwood. (Necklace poplar. Carolina poplar.)
Populus deltoides.

Western cottonwood.
Populus deltoides occidentalis.

Lombardy poplar.
Populus nigra Italica or
P. Dilatata.

Swamp poplar. (Downy-leaved poplar.)
Populus heterophylla.
Lance-leaf cottonwood and narrow-leaf cottonwood.
Populus acuminata. *Populus angustifolia.*

OAK FAMILY. CUPULIFERAE.

BIRCHES. GENUS BETULA.

River birch. (Water birch. Red birch.)
Betula nigra.
European white birch.
Betula alba.

ALDERS. GENUS ALNUS.

Sea side alder.
Alnus maratima.

Smooth alder.
Alnus rugosa or *A. serrulata.*

HAZELNUTS. GENUS CORYLUS.

Wild hazlenut or common hazlenut.
Corylus Americana.

HORNBEAMS. GENUS CARPINUS.

American hornbeam. (Blue or water beech.)
Carpinus Caroliniana.

HOP HORNBEAM. GENUS OSTRYA.

Iron-wood. (American hop-hornbeam.)
Ostrya Virginiana.

OAKS. GENUS QUERCUS.

Red oak.
Quercus rubra.

Southern red oak. (Schneck's oak.)
Quercus Texana.

Pin oak. (Swamp oak.)
Quercus palustris.

Spanish oak.
Quercus digitata, or
Quercus falcata.

Yellow oak. (Black oak. Quercitron oak.)
Quercus velutina.
Black jack oak. (Barren oak.)
Quercus Marilandica or *Quercus nigra.*
Water oak. (Duck oak. Possum oak.)
Quercus nigra or *Quercus aquatica.*

Willow oak.
Quercus phellos.

Shingle oak.
Quercus imbricaria.

White oak.
Quercus alba.
Post oak. (Rough or box white oak.)
Quercus minor or *Q. obtusiloba* or *Q. stellata.*

CORRELATION OF THE OIL SANDS IN OKLAHOMA.

CONTENTS.

Pag
Introduction
Methods of correlation
Well logs
Oil sands
Geological formations
  General problems in the correlation of sands in the Pennsylvanian
  Discussion of the oil sands and associated horizons from oldest to youngest
    Simpson sandstone
    Mississippi lime
    Pennsylvanian sands
      Bartlesville sand
      Wheeler sand
      Layton sand
      Ponca and Newkirk sands
    Miscellaneous sands
Summary
Well logs

ILLUSTRATIONS.

Pa
Plate I. Chart showing correlation of oil sands in Oklahoma

[illegible]	[illegible] N.	11 E.
Red Fork	19 N.	12 E.
Colbert	19 N.	12 E.
Muskogee	14 N.	[illegible] E.
Ada	4 N.	6 E.
Allen	6 N.	8 E.
Poteau	7 N.	26 E.
Wewoka	8 N.	8 E.

Correlation of Oil Sands in Oklahoma.

by Fritz Aurin.

RA

TOW

	Name of Formation.		Name of sand or horizon.	Corre with nam
CRE-TACEOUS	TRINITY.		Sand	
PERMIAN.	REDBEDS.	[illegible]	Sand	
			Sand	
			Sand	
			Sand	
			Sand.	
		[illegible]	Sand	
	?		Sand.	
	UNDESCRIBED SERIES ABOVE HERINGTON LS.		Sand.	
			Sand.	
	GARRISON FORMATION		Blackwell	
	ESKRIDGE SHALE.		[illegible]	
			Sand	
	ELGIN SANDSTONE.		Newkirk	Elgin
	BUXTON FORMATION.		Sand.	
			Sand.	
			Ponca	
	PAWHUSKA		Musselman	

CORRELATION OF THE OIL SANDS IN OKLAHOMA.

INTRODUCTION.

The study of subsurface geology is becoming an important phase of economic and stratigraphic geology. When new fields are opened, considerable prospecting follows in that and other areas, and the geologist undertakes to make reconaissance surveys. Much of the vital information is passed by in such hasty examinations. Detailed work is essential for accuracy and the structure must be carefully mapped before the location of any wells can be made with certainty. After a field has been developed, a study of the sands and other features of subsurface geology can be made, and is of much benefit in further development.

There are certain areas where the surface indications are insufficient to determine the structure, hence the well records are of the utmost importance. From the well records, certain horizons can be correlated and knowing the elevation at the top of the well, it is a simple matter to contour the horizon.

Realizing the need of specialization in oil geology, some of the large oil companies are establishing departments of subsurface geology as branches of the geologic divisions.

This discussion on the correlation of oil sands of Oklahoma is preliminary to later work which is now in progress, and will probably be issued at some future date as a bulletin.

METHODS OF CORRELATION.

Correlation of oil sands is a subject which takes into consideration many phases of geology. Formations are correlated on paleontological, paleobotanical, stratigraphical, or lithological data, any one or all of which may be used; or possibly from data other than that mentioned. Oil sands, on the other hand, cannot be correlated by all these methods. In fact, only a few can be employed.

The only way in which paleontology and paleobotany are used is in a correlation of the surface formations. There are exceptions to this. For example, many cases have been reported where fossils have been encountered in drilling wells. Data of this nature are important and conclusive if the fossils are typical and characteristic of a formation already studied at the surface, or encountered in drilling a well in another locality. It is apparent that this method, if possible to use, would be the best and most nearly correct. However, its use in this respect is very limited as a means of correlation of oil sands.

Some oil sands may be correlated if certain characteristic formations either above, below, or near, as the case may be, the oil sands may be recognized. Correlations by this method would be rather indefinite or open to doubt in many instances. Generally, it is necessary to use this method, on account of insufficient data to correlate by other means.

Oil sands are correlated more on lithological data than on any other. It is the most practical method, yet may lead to a serious error if other things are not considered. As an example, the logs of two wells eight miles apart are being compared. Certain limestones occur in both wells and if they were considered together there is a chance for error by mistaking one limestone for another. In this case other methods ought to be used in addition to that already employed. Then again, a formation may be found to change in character from place to place. A limestone may grade into a shale, then to a sandstone, or the reverse may take place. There is also a chance for it to differ materially in thickness or pinch out and then come in again in the section. There are so many variations that to correlate any horizon on lithological data alone would be questionable.

To correlate oil sands we see that it is necessary to use all available data. One method may be sufficient, but to have a correct correlation the surface geology, general and local, changes in dips, characteristic horizons in the logs, altitudes of the wells, and any other data should be used if possible. All these relations can be best shown by platting in columnar form the available well logs showing the data as mentioned above, then by a direct comparison correlations can be made with some degree of accuracy.

WELL LOGS.

As previously stated, the correlations depend upon well logs, together with the altitudes of the wells and surface geology. The log, being the most important factor, should be detailed and accurate. The inaccuracy of logs is one of the problems confronting one in this kind of work. It is a known fact that many drillers do not pay very much attention to the accuracy of the log. For example, in off-set wells drilled by different parties a comparison of the logs will show that the horizons vary in every manner, or may be present in one and missing in another. Many drillers will be confused as to the lithological character of the horizons. For instance, they may call a sandy shale a sand, shale, red rock, or most anything. Perhaps some mistakes can be accounted for, as it is not to be expected that drillers have a scientific knowledge of all rocks and their differentiation. In using a log, all these things must be considered and due allowance given for errors.

OIL SANDS.

An oil sand, as defined by common use, is a porous rock containing oil. This definition would be applicable to a limestone if it contained oil. In many instances drillers have reported great thicknesses of dry oil sands. These are not to be considered oil sands, according to the definition, but may, however, be classified as a sand consisting of the proper-sized grains and of sufficient amount of pore space for the rock to serve the purpose of an oil reservoir if the oil were present.

It often happens that one well will prove a "gusher," while another near by, at the same depth and in the same sand, comes in dry. This may be attributed to several causes, the chief of which is that the drill has pierced a close-grained or non-porous part of the reservoir rock.

GEOLOGICAL FORMATIONS.

The geology which is of particular interest to the practical oil man is the extent of formations which are or may be productive of oil and gas. The one series of rocks in Oklahoma that is of special importance from this standpoint is the Pennsylvanian. Practically all of the productive horizons in the Oklahoma fields are from the Pennsylvanian. There are four general areas of exposed Pennsylvanian; The area north of Arkansas River, the area south of Arkansas River, the area north of the Choctaw fault, and the area south of the Arbuckle Mountains.

GENERAL PROBLEMS IN THE CORRELATION OF SANDS IN THE PENNSYLVANIAN.

Several questions arise as to the extent and interval between succeeding formations, and also as to the constancy and correlation of horizons as the formations are traced westward and southward from the northeastern part of Oklahoma. The Cherokee formation, which is the approximate equivalent of the Vinita formation, has a thickness of 450 feet at the southern Kansas line. Southward from this point they thicken rapidly to at least 1,000 feet at Pryor Creek and continue to thicken southward. In the Muskogee quadrangle the Winslow and Boggy formations, about 1,500 feet in thickness, are correlated by Taff with the Cherokee formation. In the Coalgate quadrangle Taff has correlated the Atoka, Hartshorne, McAlester, Savanna, and Boggy formations with the Cherokee. Thus the Cherokee, which has a thickness of 450 feet at the Kansas line, is equivalent to the 9,000 feet of sediments from the base of the Atoka to and including the Boggy. Siebenthal makes the same correlation. On the other hand, Ohern says: "I cannot agree with Siebenthal in saying that in the Coalgate and Atoka quadrangles these 9,000 feet of Pennsylvanian shales and sandstones are represented at the Kansas line by a thickness of but 500 feet of Cherokee. Assuming the verity of his correlation of the Fort Scott of Kansas with the Calvin sandstone of Coalgate quadrangle, still his statement is probably not correct; for the relation of the Vinita formation to the Mississipian below is for the most part, at least, one of overlap. Thus as one follows the Mississippian-Pennsylvanian contact line southward and eastward from the Kansas line, successively older formations appear from beneath those overlying. At most, then, the Cherokee shales can be the equivalent of only a part of the 9,000 feet of Pennsylvanian sediments near Coalgate."

It would appear, then, that productive horizons near the base of the Pennsylvanian encountered in the territory to the north of Muskogee and Okmulgee counties are not the same as the basal horizons encountered in the above-mentioned counties. The writer takes this view, and the correlations as platted on the chart have been made with that in mind.

DISCUSSION OF THE OIL SANDS AND ASSOCIATED HORIZONS FROM OLDEST TO YOUNGEST.

SIMPSON SANDSTONE.

The Simpson sandstone, in the Arbuckle Mountains, and of Ordovician age, is the oldest oil horizon in Oklahoma. As found in places in the Arbuckle Mountains, certain horizons in the Simpson formation are impregnated with asphalt. In this respect it may be considered as a fossile oil sand, but in the Healdton field there is a possibility, according to some geologists, of the Simpson being a productive horizon.

MISSISSIPPIAN LIME.

The "Mississippi lime" of the drillers may be either the Pitkin limestone, limestone in the Fayetteville shales, the Mayes limestone, or the Boone chert. Drilling is usually discontinued when the driller is satisfied that these horizons have been reached. As before stated, oil and gas are not definitely known to occur in, or below these horizons, and in nearly every case where they have been penetrated strong flows of salt water have been encountered. It is probably true that drilling is often discontinued when some of the limestones in the Lower Pennsylvanian are encountered and mistaken for the "Mississippi lime."

PENNSYLVANIAN SANDS.

The oldest sands in the Pennsylvanian occur in the Morrow formation. In the Beland pool two gas sands have been referred to this horizon. One is encountered at a depth of 1,500 feet, and the other at 1,745 feet.

Only brief reference is given to the succeeding sands with their correlations. Some of the main productive horizons will be discussed.

BARTLESVILLE SAND.

The Bartlesville sand is the most widely known oil sand in the State, and more oil has been produced from this sand than from any other horizon in Oklahoma. This sand occurs near the base of the Cherokee formation. The heavy sandstone outcropping east of Welch, at Bluejacket and northwest of Vinita, is probably the Bartlesville. It has been recognized to the westward through Osage County, as far as the drilled areas in Kay County, and to the southwest in the Cushing field, where it has proven the sand of big production. In the latter field it occurs at depths from 2,400 to 2,800 feet. This formation is not an oil sand in all of its areal extent, although the term is very properly applied to the strata occurring at this horizon.

WHEELER SAND.

The Wheeler "sand" of the Cushing field is a good example of formations other than true sands forming oil reservoirs. This sand, which changes in character from an impure limestone to a sandy lime. is probably the equivalent of the Fort Scott or Oswego lime, which is one of the most constant formations underlying practically the entire oil and gas area of northeastern Oklahoma.

LAYTON SAND.

The Layton sand, which has been extensively developed in the Cushing field, probably occurs in the Curl formation. This sand, or its equivalent, has been recognized in various fields in northeastern Oklahoma. At Wynona a sand encountered at a depth of 1,180 feet is probably the Layton or its equivalent. The same is encountered in the Boston, Cleveland, Cushing, Yale, Ripley, Ponca City, and Blackwell fields at depths of 1,240, 1,300, 1,480; 1.975, 2,072; 2,300 and 2,655 feet; respectively.

PONCA AND NEWKIRK SANDS.

The Ponca sand probably occurs in the Buxton formation. At Ponca City this sand is productive of both oil and gas and is encountered at a depth of about 1,550 feet. In the Blackwell field a sand encountered at a depth of about 1,960 feet is probably the Ponca.

The Newkirk sand, which is the equivalent or a part of the Elgin sandstone, is encountered in the Newkirk field, where it is productive of oil at a depth of 900 feet. In the Ponca City and Blackwell fields it is encountered at depths of 975 and 1,440 feet, respectively.

MISCELLANEOUS SANDS.

In the Healdton field about 7 sands productive of oil and gas have been encountered. The deepest is that of the 2000-foot sand encountered in the Fox district. Other sands are encountered at the following depths: 725. 781, 820, 925, 1,040, 1,070 feet. Several other sands are also encountered. It is thought that all these sands, with possibly the exception of the deepest sands, occur in the Permian Redbeds.

In the Wheeler, Duncan, Gotebo, and Lawton fields various oil sands have been encountered in the Permian Redbeds.

The highest stratigraphic productive sand in Oklahoma is that of the 450-foot sand in the Madill pool. This sand occurs in the Trinity sand of Lower Cretaceous age.

SUMMARY.

Data have been collected from most of the important fields of the State. The interpretation of these data is shown on the correlation table accompanying this publication.

The writer is especially indebted to Messrs. Fohs and Gardner, Tulsa, Okla., for information furnished from their correlations of Oklahoma oil sands.

WELL LOGS.

The following well logs are given to show the general characteristics of the oil and gas fields of Oklahoma.

Tammany, Wm. Lowe, No. 2, in sec. 12, T. 14 N., R. 12 E.

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Soil	5	5	Sand	25	1,0[illegible]5
Lime	40	45	Slate	335	1,3[illegible]0
Slate	25	70	Sand (water)	183	1,5[illegible]3
Lime	15	85	Slate	57	1,630
Shelly	40	125	Lime	5	1,635
Slate	125	250	Slate	305	1,940
Lime	20	270	Lime	10	1,950
Slate	30	300	Slate	68	2,018
Lime	15	315	Lime	20	2,038
Slate	125	440	Slate	12	2,050
Lime	10	450	Lime	20	2,070
Slate	225	675	Slate	15	2,085
Lime	25	700	Top oil sand	4	2,089
Slate	75	775	Broken sand and shells	70	2,[illegible]59
Sand	130	905			
Slate	125	1,030			

Lucinda Johnson No. 1, in NE. ¼ sec. 30, T. 22 N., R. 15 E.

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Soil	18	18	Broken sand	10	[illegible]80
Blue shale water	132	150	Shale	175	855
Lime	30	180	Sand	6	861
Black shale	5	185	Broken sand, gas	5	866
Lime	12	197	Broken sand	5	871
Shale	40	237	B. Shale	50	921
Lime	8	245	Lime	10	931
Shale	175	420	Black shale	45	976
Lime	25	445	Lime	45	1,021
White shale	40	485	Shale	10	1,031
Sand, gas	15	500	Lime	40	1,071
Shale	100	600	Shale	9	1,080
Sand, gas	15	615	Sand	10	1,090
Black shale	5	620	Lime	7	1,097
Lime	5	625	Sand	5	1,102
Broken sand	5	630	White sand (water)	30	1,13[illegible]
Shale	40	670			

Monitor Oil Company Well No. 1, *Osage County, sec.* 25, *T.* 22 *N., R.* 7 *E.*

acter of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
	20	20	Sand	15	895
	5	25	Slate	15	910
ck	40	65	Sand	105	1,015
	40	105	Slate and sand	35	1,050
	10	115	White slate	20	1,070
	20	135	Sand and slate	25	1,095
	60	195	Lime	3	1,098
	155	350	Blue slate	69	1,167
ck	15	365	Lime	38	1,205
	7	372	Blue slate	50	1,255
ck	23	395	Sand	15	1,270
ate	30	425	Slate	25	1,295
	6	431	Sand	22	1,317
	19	450	Slate	183	1,500
	10	460	Layton sand	50	1,550
	27	487	Slate	194	1,744
	9	496	Lime	8	1,752
	74	570	Slate	38	1,790
	15	585	Cleveland sand	35	1,825
	37	622	Slate and sand	75	1,900
late	18	640	Sand	30	1,930
nd slate	47	687	Slate	60	1,990
	23	710	Oswego lime	65	2,055
ate	90	800	Slate	10	2,065
	18	818	Oswego lime	45	2,110
	7	825	Slate	55	2,165
nd sand	30	855	Peru sand	13	2,178
	25	880			

Stevens No. 1, *in sec.* 9, *T.* 14 *N., R.* 18 *E.*

cter of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
rded (water)		160	Slate	10	1,490
		450	Lime	15	1,505
	20	470	Sand (water)	65	1,570
lack	155	625	Slate	20	1,590
	10	635	Lime, white	80	1,670
	265	900	Slate, black	20	1,690
	30	930	Lime shells	125	1,815
	75	1,005	Shale, brown	85	1,900
ells	10	1,015	Sand, black	65	1,965
hard	20	1,140	Slate, sandy	35	2,000
	70	1,210	Slate, black	36	2,036
	20	1,230	Sand	12	2,048
lack	20	1,250	Slate	42	2,090
	50	1,300	Sand	80	2,170
	15	1,315	Slate	10	2,180
	60	1,375	Sand, green	40	2,220
	15	1,390	Red rock	55	2,275
	30	1,420	Slate	25	2,300
	45	1,465	Lime	40	2,340
	15	1,480	Lime, sandy	45	2,385

McCroskey No. 1, SE. cor. NW. ¼ sec. 7, T. 19 N., R. 6 E., Alice-Kathryn Oil Co.

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Surface	20	20	Red rock	14	1,365
Lime shell	3	23	Sand, water	28	1,393
Red rock	17	40	Blue slate	5	1,398
Lime shell	6	46	Lime shell—very hard	7	1,405
Shale	24	70	Blue slate	5	1.410
Sand—some water	15	85	Sand	15	1,425
Red rock	5	90	Lime shell	6	1,431
Sand	10	100	Blue slate	20	1,451
Shale	2	102	Lime shell	4	1,455
Gritty slate	38	140	Blue slate	5	1,460
Slate	5	145	Sand	10	1,470
Shells, water	5	150	Blue slate	3	1,473
Red rock	5	155	Lime shell, very hard	57	1,530
Shale, water	5	160	Blue shale	80	1,610
Slate	20	180	Lime shell	2	1,612
Lime shells	7	187	Sandy slate	22	1,634
Gritty shale	58	245	Lime shell	4	1,638
Lime	5	250	Sand	3	1,641
Red rock	35	285	Underreamed 23 feet	23	1,664
Blue slate	15	300	Black slate	61	1,725
Red rock	20	320	Sand, water	81	1,806
Slate and shells	60	380	Black slate	8	1,814
Sand and shells	55	435	Sand (hole full of water)	9	1,823
Blue slate	60	495	Slate	10	1,033
Red rock	10	505	Brown shale	27	1,860
Sand	20	525	Sand	5	1,865
Blue slate	110	635	Brown shale	28	1,893
Red rock	10	645	White sand	12	1,905
Sand	35	680	Shale	245	2.150
Blue slate	5	685	White sand—water	27	2,177
Red rock	15	700	Slate	221	2,398
Sand	12	712	Sand (some oil)	37	2,435
Blue slate	123	835	Black slate	130	2,565
Sand	30	865	Gritty shale	35	2.600
Sand shale	25	890	Black slate	118	2.718
Red rock	5	895	Lime	57	2,775
Shale	15	910	Slate	20	2,795
Sand	50	960	Lime	40	2,835
Lime and slate	77	1,037	Black slate	5	2,840
Sand broken	9	1,046	Lime	14	2,854
Blue slate	12	1,058	Sand and water	46	2.900
Red rock	43	1,101	Slate	127	3.027
Lime shell	1	1,102	Sand	15	3.042
Red rock	2	1,104	Sandy shale	18	3.060
Red rock	21	1,125	Lime	5	3,065
Sand, water	26	1,151	Blue slate	20	3.085
Red rock	37	1,188	Shale	42	3,127
Lime shells	10	1,198	Sand, dry	20	3,147
Blue slate	62	1,260	Sand, oil	22	3,169
Sand	48	1,308	Black shale	115	3.284
Slate	43	1.351			

Log of Alberta No. 1, *SE.* ¼ *sec.* 32, *R.* 29 *N., R.* 1 *E.*

acter of rock.	Thickness.	Depth.
	Feet.	*Feet.*
	55	55
m	15	70
slate	30	100
	10	110
	30	140
	15	155
	45	200
	25	225
	25	250
ock	25	275
	15	290
	10	300
	25	325
	8	333
	7	340
lime (gas and r)	30	370
ock	35	405
and slate	15	420
	15	435
	15	450
sand	35	485
rock	30	515
shale	5	520
	5	525
rock	35	560
	10	570
rock	20	590
	30	620
ock	25	645
	25	670
rock	20	690
	65	755
shale	5	760
(gas at 775)	95	855
	95	950
	10	960
	40	1,000
	25	1,025
shale	25	1,050
	10	1,060
shale	110	1,170
	70	1,240
	20	1,260
	20	1,280
	45	1,325
	10	1,335
	40	1,375
	35	1,410
	15	1,425
(gas, 10 mil. water)	20	1,445
Shale	45	1,490
Lime	10	1,500
Shale	75	1,575
Lime	25	1,600
Shale	10	1,610
Lime	35	1,645
Shale	5	1,650
Lime	50	1,700
Blue shale	35	1,735
Sand gas)	15	1,750
Shale	40	1,790
Sand	15	1,805
Shale	60	1,865
Lime	40	1,905
Red rock	30	1,935
Sand (some gas)	30	1,965
Red rock	10	1,975
Slate	25	2,000
Lime	5	2,005
Slate	30	2,035
Lime	10	2,045
Slate	5	2,050
Lime	30	2,080
Slate	30	2,110
Sand	15	2,125
Slate	60	2,185
Lime	15	2,200
Slate	80	2,280
Sand (showing of oil	10	2,290
Slate	15	2,305
Sand (water)	70	2,375
Sand	25	2,400
Shale	250	2,650
Sand (gas 2 million feet)	15	2,665
Sand, oil	10	2,675
Sand (water at 2700	75	2,750
Lime	15	2,765
Slate	35	2,800
Lime	70	2,870
Slate	15	2,885
Slate	45	2,930
Lime	50	2,980
Shale	50	3,030
Sand (oil showing)	30	3,050
Lime	130	3,180
Lime, caprock	100	3,280
Sand, gas	25	3,305
Sand, oil	15	3,320
Shale	40	3,360
Sand, oil	25	3,385

W. B. Pine No. 1, one-half mi. S. of Henryetta, in T. 11 N., R. 12 E.

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Soil	10	10	Sand, white, (heavy paraffin, oil and gas	11	1,027
Slate, white	91	101	Slate, white (lime shells)	865	1,892
Limestone, hard, gray	4	105	Sand, white, dry	15	1,907
Slate, soft, white	100	205	Limestone, hard, gray	101	2,008
Slate, soft, grayish blue	197	402	Slate, soft, white	5	2,013
Sand, white, (water)	32	434	Limestone, hard, gray	7	2,020
Shale, white	76	510	Coal, fine quality	4	2,024
Shale, grayish, blue	355	865	Limestone, hard, gray	252	2,276
Sand, white, (water)	45	910	Slate, soft, gray	30	2,306
Slate, soft, white	50	960	Lime shell, hard, sandy	3	2.309
Slate, hard, gray	56	1,016			

Log of Mid-Co. Petroleum Co.'s No. 1 well in the N. ½ SW. ¼ sec. 22, T. 23 N., R. 2 W., near Billings, Okla.

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Earth	6	6	Red rock	56	696
Lime	24	30	Hard slate	19	715
Sand	4	34	Red rock	25	740
Slate	16	50	Gas sand	15	755
Red rock	10	60	Slate	10	765
Blue slate	37	97	Soft gray lime	42	807
White shale	13	110	Red rock	23	830
Red rock	5	115	Gas sand	12	842
Slate	20	135	Red rock	18	860
Red rock	105	240	Hard sand and gas	10	870
White slate	10	250	Red rock	14	884
Red rock	15	265	Hard, gritty lime, gas	21	905
Lime	4	269	Hard slate	10	915
Red rock	46	315	Red rock	112	1,027
Slate	10	325	Gas sand	20	1,047
Red rock	5	330	Blue slate	2	1,049
White slate	8	338	Sand and lime	17	1,066
Red rock	17	355	Red rock	64	1,130
Soft slate	10	365	Lime	6	1,136
Soft red rock	15	380	Red rock	14	1,150
Lime	8	388	First water sand;		
Sand rock	7	395	water salty	20	1,170
White slate	25	420	Slate	25	1,195
Hard lime	15	435	Lime	23	1,218
Soft lime	15	450	Red rock	52	1,270
White slate	42	492	Lime	30	1,300
Red rock	28	520	Brown slate	15	1,315
Gray lime	15	535	Lime	75	1,390
Red rock	25	560	Blue slate	5	1,395
Hard slate	10	570	Lime	5	1,400
Gas sand	12	582	Lime and slate	76	1,476
Red rock	38	620	Gas sand	69	1,545
Blue lime	5	625	Slate	25	1,570
Hard sand	15	640			

Jemima Richards No. 3, SW. of the N. ½ of sec. 3, T. 17 N., R. 7 E.

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Sand	54	54	Lime	9	729
Slate	46	100	Lime	3	732
Lime	5	105	Sand	17	749
Slate	15	120	Lime	4	753
Red rock	48	168	Sand	7	760
Slate	12	180	Slate	16	776
Sand	25	205	Sand	24	800
Slate	29	234	Slate	3	803
Sand	23	257	Sand	7	810
Lime	5	262	Lime	2	812
Sand	22	284	Sand	6	818
Lime	10	294	Slate	62	880
Sand	6	300	Lime	5	885
Slate	5	305	Sand (water)	13	898
Red rock	9	314	Slate	14	912
Slate	21	335	Sand	41	953
Lime	4	339	Slate	16	969
Slate	29	368	Lime	4	973
Red rock	22	390	Sand	39	1,012
Sand	20	410	Slate	13	1,125
Slate	5	415	Slate	201	1,326
Sand	20	435	Lime	6	1,332
Slate	26	461	Slate	15	1,347
Sand	13	474	Sand (Layton)	40	1,387
Slate	15	489	Shale	5	1,392
Lime	21	510	Slate	169	1,561
Sand	20	530	Lime	4	1,565
Slate	4	534	Sand (Cleveland)	12	1,577
Sand	12	546	Slate	444	2,021
Slate	22	568	Wheeler sand	14	2,035
Lime	8	576	Break	12	2,047
Slate	14	590	Lime (2nd gas)	43	2,090
Lime	30	620	Slate	106	2,196
Sand	7	627	Lime	3	2,199
Slate	8	635	Slate	101	2,300
Lime	12	647	Sand (water)	1	2,301
Slate	10	657	Slate	95	2,396
Sand	33	690	Sand (gas)	15	2,411
Slate	20	710	Slate	20	2,431
Lime	10	720	Bartlesville sand*	54	2,485

*Entire production 110 bbls. per hour.

Jack Summers No. 1, in sec. 17, T. 15 N., R. 14 E.

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Shale	200	200	Sand	186	1,176
Lime	10	210	Slate	224	1,400
Sand	15	225	Sand	175	1,575
Slate	650	875	Slate and lime shells	105	1,680
Sand	30	905	Sand	5	1,685
Slate	85	990	Slate and lime shells	60	1,745

Log of Tulsa County well, 250 *feet N. and* 200 *feet W. of SE. cor. sec.* 25, *T.* 19 *N., R.* 11 *E.*

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Surface	20	20	Black shale	3	1,077
Sandstone and yel. soil	20	40	Lime shell	83	1,160
Blue shale	20	60	Brown shale	9	1,169
Gray sandy shale	240	300	Lime shell	181	1,350
Dark shale	24	324	Brown shale	3	1,35[illegible]
Water sand	36	360	Lime shell	27	1,380
Blue shale	8	368	Black slate	165	1,54[illegible]
Lime shell	32	400	Brown and white shale	3	1,548
Blue shale	40	440	Lime shell	102	1,650
White sandy shale—show of gas	360	800	Blue shale	3	1,65[illegible]
Brown shale	30	830	Lime shell	122	1,77[illegible]
Black slate	50	880	White and blue shale	108	1,88[illegible]
Big lime	145	1,025	Taneha sand	14	1,89[illegible]
Sandy shale	33	1,058	Blue and black shale	22	1,91[illegible]
Oswego lime	16	1,074	Oil sand	4	1,92[illegible]

Log of well, 101 *Ranch, in NE.* ¼ *sec.* 25, *T.* 25 *N., R.* 1 *E.*

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Sandy soil	19	19	Black slate	6	742
Gravel	40	59	Hard lime	38	780
White clay (water)	10	69	White slate	50	830
Red rock	12	81	Grayish lime	24	854
Gritty slate	8	89	Black slate with shells	18	872
Red rock	21	110	Black slate with hard shells	24	[illegible]96
White shale or clay	42	152	Black slate	6	[illegible]02
Lime shell	9	161	Slate and shells	21	[illegible]23
White shale or clay	44	205	Reddish tinted slate	37	[illegible]60
Red rock	26	231	Gritty shell in black slate	45	1,[illegible]05
Lime shell	3	234	White and black sand	12	1,[illegible]17
Red rock	60	294	Black slate	45	1,[illegible]62
Brownish lime	4	298	Slate and shell	4	1,[illegible]66
Hard black slate	28	326	Soft slate	85	1,161
Reddish lime	24	350	Lime	4	1,[illegible]55
Red rock	35	385	Very soft slate	75	1,230
Gritty slate	20	405	Hard white sand	6	1,236
Red rock	22	427	Soft black slate	24	1,260
White shale	8	435	Dark soft shale	12	1,272
Brownish lime	8	443	Lime cavings	43	1,315
Hard grayish lime	22	465	White sand (water)	19	1,334
Red shale	35	500	Slate and shells	33	1,367
Lime shell	12	512	Hard lime	18	1,385
Red rock	58	570	Soft dark lime	10	1,395
Red sand	23	593	Soft black shale	23	1,418
Hard white lime	5	598	Red rock	15	1,4[illegible]3
Red shale	27	625	White sand	17	1,450
White sand	35	660	Black slate	10	1,460
Red shale	42	702			
White sand	34	736			

well, 101 *Ranch*, *in NE.* ¼ *sec.* 25, *T.* 25 *N.*, *R.* 1 *E.*—Continued.

ter of rock.	Thickness.	Depth	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
rd sand	56	1,516	Lime shell	3	2,018
hale	6	1,522	Sandy lime	19	2,037
rd sand	7	1,529	Brown shale	3	2,040
le	20	1,549	White sand	5	2,045
and (water)	28	1,577	White shale	13	2,058
ale	3	1,580	White sand	30	2,088
me	5	1,585	Black shale	20	2,108
ate	53	1,638	Hard lime	6	2,114
ime	25	1,663	Black slate	49	2,163
ck shale	22	1,685	Hard shell	3	2,166
le	5	1,690	Black slate	14	2,180
and	15	1,705	Hard white sand	10	2,190
ate	3	1,708	Red brown shale	4	2,194
and	28	1,736	White slate	5	2,199
hale	20	1,756	Very hard white lime (water)	43	2,242
ell	7	1,763			
ck shale	36	1,799	Black slate	26	2,268
and (water)	39	1,838	Dark lime	11	2,279
le	4	1,842	Black shale	3	2,282
ray lime	10	1,852	White sand (salt water)	18	2,300
hale	6	1,858			
d shell	22	1,880	Dark shale	3	2,303
ck shale	5	1,885	Very white sand	59	2,362
le	7	1,892	Dark black shale	43	2,405
ime	30	1,922	Dark lime	6	2,411
ck shale	13	1,935	Blue shale	54	2,465
shale	15	1,950	White shale	20	2,485
me	28	1,978	Dark blue shale	35	2,520
cavings	22	2,000	White sand	56	2,576
ay lime	15	2,015			

ert Whiteturkey No. 2, *in NE. cor. sec.* 18, *T.* 26 *N.*, *R.* 13 *E.*

ter of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
ded	42	42	Break	12	618
	28	70	Lime (little gas)	34	652
	30	100	Slate, black	2	654
ight	95	195	Lime	5	659
	10	205	Shale	6	665
ight	145	350	Sand	15	680
	4	354	Shale	112	792
	5	359	Lime, Big	33	825
	6	365	Slate, black	6	831
	27	392	Lime, Big, (little gas)	23	854
	5	397	Break	6	860
lack	8	405	Lime, hard	9	869
	18	423	Slate, black	20	889
ight	15	438	Oil sand	24	913
	30	468	Slate, black	6	919
ight	114	582	Lime, hard	9	928
	24	606	Slate, black	15	943

Albert Whiteturkey No. 2, *in NE. cor. sec.* 18, *T.* 26 *N., R.* 13 *E.*—Continued.

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Shale	37	980	Shale, sandy	45	1,145
Shell, hard	5	985	Slate, black	17	1,162
Slate	17	1,002	Sand, gas	7	1,169
Shell, hard	3	1,005	Slate	26	1,195
Shale, light	45	1,050	Sand	89	1,284
Shell	3	1,053	Sand, oil	7	1,291
Shale, light	37	1,090	Slate and shale	83	1,374
Slate, black	10	1,100	Miss. lime, Total depth		1,378

Margaret Primeaux No. 1, *in sec.* 4, *T* 25 *N., R.* 2 *E*

Character of rock.	Thickness.	Depth.	Character of rock.	Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Soil	4	4	Lime	9	758
Clay	40	44	Slate	2	760
Sand and gravel	6	50	Lime	25	785
Lime	20	70	Slate	74	859
Red rock	45	115	Shell	9	868
Shell	5	120	Slate	35	903
Red rock	40	160	Shell	3	906
Lime	5	165	Slate	26	932
Slate	10	175	Lime	3	935
Red rock	59	234	Sand	15	950
Sand (gas)	20	254	Slate	25	975
Red rock	10	264	Lime	10	985
Slate	5	269	Slate	60	1,045
Lime	5	274	Black shale	15	1,060
Slate	13	287	Lime	10	1,070
Red rock	12	299	Slate	60	1,130
Lime	46	345	Shale	15	1,145
Red rock	20	365	Slate	75	1,220
Gas sand	12	377	Lime	15	1,235
Slate	2	379	Slate	25	1,260
Lime	4	383	Lime	15	1,275
Slate	30	413	Red rock	4	1,279
Red rock	42	455	Lime	2	1,281
Lime	10	465	Slate	10	1,291
Red rock	2	467	Lime	15	1,306
Lime	6	473	Slate	12	1,318
Red rock	69	542	Lime	2	1,320
Gas sand	12	554	Red rock	2	1,322
Red rock	18	572	Sand (gas)	10	1,332
Lime	4	576	Slate	20	1,352
Slate	17	593	Lime	10	1,362
Lime	5	598	Slate	35	1,397
Lime	42	640	Lime	15	1,412
Slate	5	645	Slate	10	1,422
Red rock	6	651	Lime	8	1,430
Slate	8	659	Slate	5	1,435
Lime	10	669	Lime	8	1,443
Red rock	10	679	Lime	17	1,460
Lime	26	705	Lime	27	1,487
Slate	8	713	Slate	6	1,493
Lime	10	723	Lime	3	1,496
Sand	20	743	Slate	10	1,506
Break	2	745	Sand	20	1,526
Sand (little gas)	4	749	Black slate	4	1,530
			Oil Sand	19	1,549

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OKLAHOMA GEOLOGICAL SURVEY.

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CIRCULAR NO. 8.

METHODS OF EXPLORING FOR OIL AND GAS.

By GEORGE E. BURTON.

COSTS OF DRILLING OIL AND GAS WELLS.

Compiled by
OKLAHOMA GEOLOGICAL SURVEY.

NORMAN.
July, 1917.

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ILLUSTRATIONS.

Plate I. Diamond drill and equipment 7
Plate II. Double tube core barrel, showing core of material passed through 9

Figure 1. Showing method for dip and strike calculations from drill hole records 11
Figure 2. Showing method for dip and strike calculations from drill hole records 14

Note.—Plates I and II furnished through courtesy of the Sullivan Machinery Company, Chicago, Illinois.

METHODS OF EXPLORING FOR OIL AND GAS.

By George E. Burton.*

PRESENT METHODS.

There are in Oklahoma at present two general methods of exploring for oil and gas: (1) securing a block of leases and making one or more churn drill tests; and (2) geological examination of the surface in search of anticlines or other favorable structures in which oil or gas might accumulate. Then, if favorable structure is found, churn drill holes are drilled at favorable locations on the structure.

Although the first method has to its credit a long list of dry holes, the great Glenn pool, the Healdton field, and other pools were discovered in this way. However, the chances of finding production by this method of exploration are small. The second method has to its credit the discovery of several oil and gas pools, among which are parts of the famous Cushing field, the Blackwell and Ponca City fields, and the new Garber and Billings pools.

It is interesting to note that structure contours drawn at the horizon of the productive sands in the Healdton field disclose anticlinal structure beneath the surface. This shows that anticlinal structure may exist at depth, in areas where there are no surface indications of such structure.

The first method of exploration, although it has some discoveries to its credit, is too expensive in proportion to the favorable results obtained, to remain in favor much longer with the increasing price of supplies and the cost of drilling.

It is generally conceded by petroleum geologists that the surface in the possible oil and gas territory in Oklahoma has been pretty thoroughly examined, that most of the favorable structures have been located, and that the lands overlying such structures have been practically all leased. So it seems that the end of the second method is in sight. The petroleum geologist using this method of exploration has been confined to those areas, within the probable oil and gas territory in Oklahoma, where there are **reliable outcrops.** Reliable outcrops are outcrops of those strata which were, during the process of sedimentation, deposited horizontally, but which may have since become inclined or folded. The positions of such strata, as observed at the surface outcrops, show their relation to the horizontal, a definite datum plane. Where sufficient outcrops of these reliable strata occur, the geologist can work out the structure and point out the location of anticlines or other folds, and make a fairly definite location for a test well.

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*Assistant Director, Oklahoma Geological Survey, Norman, Oklahoma.

As mentioned above, however, this work is confined to areas where reliable outcrops occur. This method does not cover vast areas where there are no outcrops, or where the outcrops are not to be depended upon for the working out of structure. What, then, is to be the method of exploring areas of this sort?

DIAMOND DRILL METHOD.

The first method of exploration mentioned is slow and expensive, and the second method does not apply in some areas. A third method is therefore proposed for consideration—a method of exploration for areas in which there are few or no surface indications of the underground structure. The method proposed is the use of the diamond core drill in exploring for favorable structure in areas where there are no surface indications of its presence or absence.

At shallow depths in such areas there are, no doubt, strata which have considerable horizontal extent, which were deposited horizontally, and which could be recognized from core. By proper spacing and careful surveying of drill holes the underground structure could be determined from the position of such strata.

The cost of this kind of exploration is entirely proportionate to the reward sought. A churn drill hole costing $20,000 was drilled in the NW. cor. sec. 30, T. 23 N., R. 6 W., by the city of Enid, Oklahoma, to a depth of 3,000 feet. This well is located in an area where there are very few outcrops, and consequently the underground structure cannot be determined from the surface. The sum total of information gained for an expenditure of $20,000 is that this particular hole is dry. There may be oil or gas within a few hundred feet in any direction from this hole. This method of exploration is obviously too expensive to continue.

As shown by the log of the Enid well, there is at a depth of 830 feet a limestone 2 feet thick, which has, no doubt, considerable horizontal extent. The Duluth Diamond Drill Company of Duluth, Minnesota, contract diamond and churn drillers, roughly estimated that they could drill with diamond drill to a depth of 1,000 feet at a cost of from $1.00 to $2.00 per foot.*

At the maximum charge per foot, the writer estimates that twelve drill holes could be put down to the 830-foot "lime" stratum in the Enid well for $20,000. By properly placing and carefully surveying these holes the attitude of this stratum could be determined over a considerable area in the vicinity of the Enid

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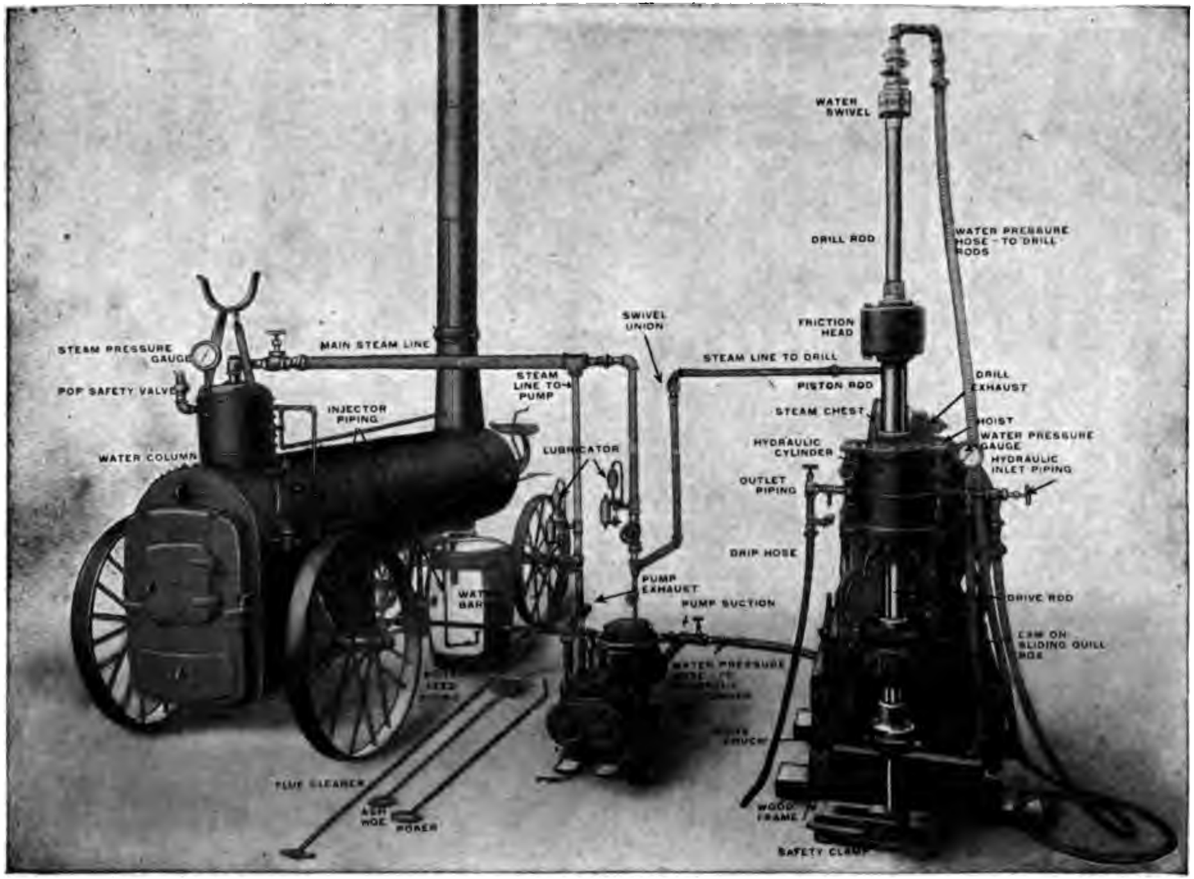
*Note: The prices for all kinds of drilling have gone up considerably since the above estimates were made. Since, however, all kinds of drilling have been influenced, the general conclusions from a comparison of figures will be the same.



DIAMOND DRILL AND EQUIPMENT.

well. It is to be understood that these figures are probably extreme. I feel sure that from the core a reliable stratum could be recognized at considerably less depth. This would permit the exploration of a larger area for the same amount of money.*

THE DIAMOND CORE DRILL.

The Diamond Core Drill consists essentially of a bit, which is a circular ring of especially prepared steel, in which are set varying numbers of black diamonds. All the remainder of a diamond drill outfit consists of devices necessary to rotate this diamond bit against the rock stratum, provide for a circulation of water down through the bit, furnish a means of recovering core, and provide for hoisting the bit from the hole. (See Plate I.)

The rotation of the bit is accomplished by an engine connected to the bit with rods. These rods are usually in 10-feet lengths. Rods are added as the depth of the hole increases. These rods are hollow. A circulation of water down through the bit is maintained by a pump connected by a hose to the upper end of the uppermost rod. The water escapes to the surface through the hole on the outside of the rods. This circulation of water accomplishes two things—keeps the bit cool and brings to the surface the "cuttings."

The core is recovered by means of a core barrel five feet long, which takes the place of the rod next to the bit. The opening in the core barrel is larger than it is in the rod. Core barrels are of two kinds, single-barrel and double-barrel. In the single-barrel type ,the water washes down around the core. This type of barrel is used when drilling in rocks hard enough to resist the washing of the water in the barrel. In the double-barrel type, the chamber in which the core accumulates is separated from the chamber in which the water circulates, except at the very bottom of the core chamber, where the water is permitted to enter near the cutting point of the bit. This arrangement permits the water to pass through the cutting part of the bit without washing down around the core. This type of core barrel is used for recovering core from very soft rocks. (See Plate II.)

The hoisting device for removing the bit from the hole consists of a derrick, in the top of which is a pulley through which operates a cable, and a drum attached to the engine. The derrick usually consists of a tripod, made of three poles, 6 to 8 inches in diameter. In hoisting, the rods are broken in ten, twenty or forty feet lengths, according to the height of the derrick.

Since diamond drill holes are apt to deflect from the vertical it is almost necessary to have a device for surveying drill holes.

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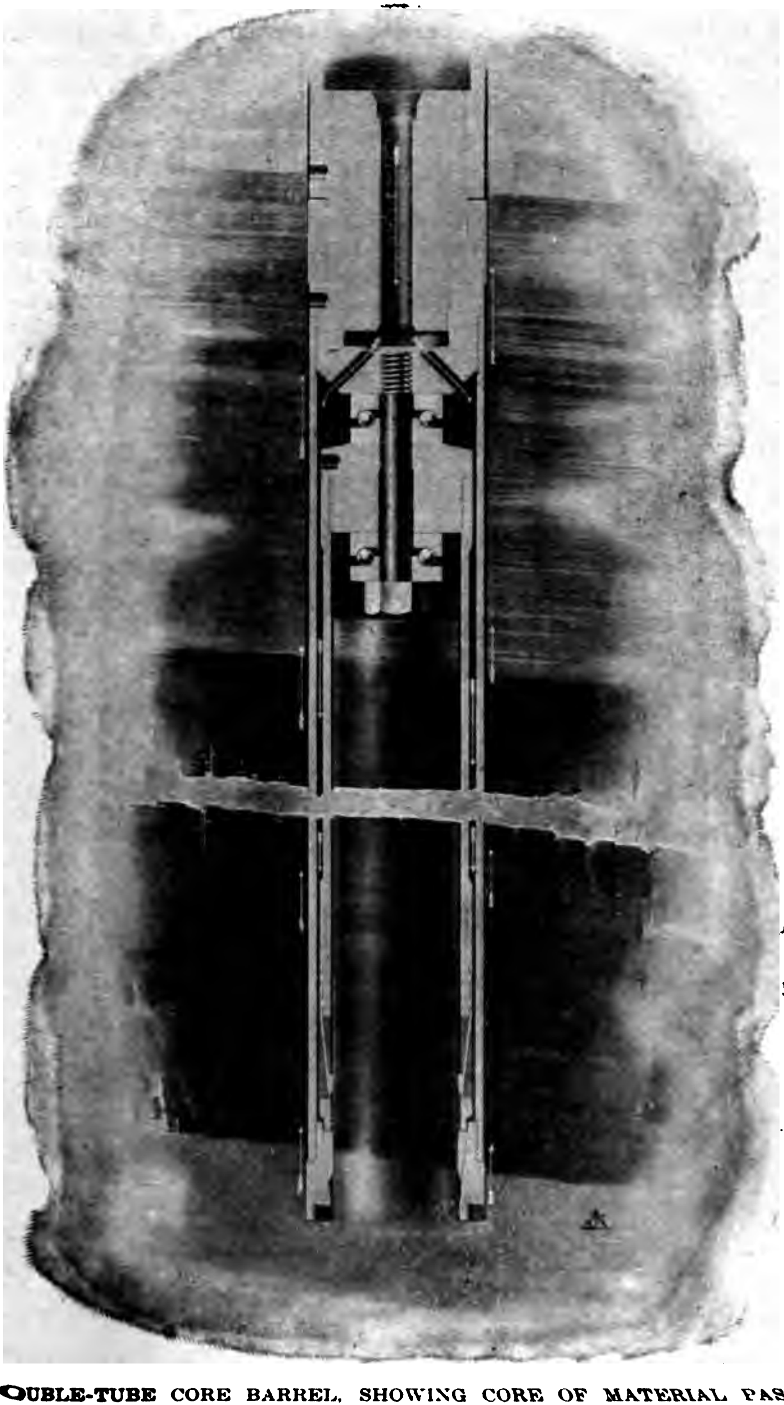
*Engineering and Mining Journal, 1917.

PLATE II



DOUBLE-TUBE CORE BARREL, SHOWING CORE OF MATERIAL PASSED THROUGH.

Such a device is the Mass compass. This compass is attached to a cork in such a way as to permit its needle free motion in gelatin. The compass is placed in liquid gelatin in one end of a glass tube. The other end of the tube contains hydroflouric acid. A rubber stopper separates the two liquids. The tube with its contents is placed in a specially designed case, which is lowered to the place in the drill hole, the position of which is desired. This is permitted to stand for some time—the time depending on the depth, permitting the gelatin to "freeze." The hydrofluoric acid etches a ring around the tube, thus showing the vertical variation; and the position of the compass in the gelatin shows the horizontal variation. From these two readings, together with the distance to the point surveyed, it is possible to determine the exact position of that point.

METHODS OF SHOWING THE ATTITUDE OF A STRATUM FROM DRILL-HOLE DATA.

There are two methods of showing the attitude of a stratum from drill hole data: (1) dip and strike readings; and (2) structural contours.

STRUCTURAL CONTOUR METHOD.

In the structural contour method the elevation of the point where the drill encounters the stratum is determined and lines are drawn at regular intervals through points of the same elevation on the stratum. The relation of these various lines indicate the attitude of the stratum.

DIP AND STRIKE METHOD.*

The following calculation is used to obtain the dip and strike of a stratum of rock from the data acquired in three drill holes:

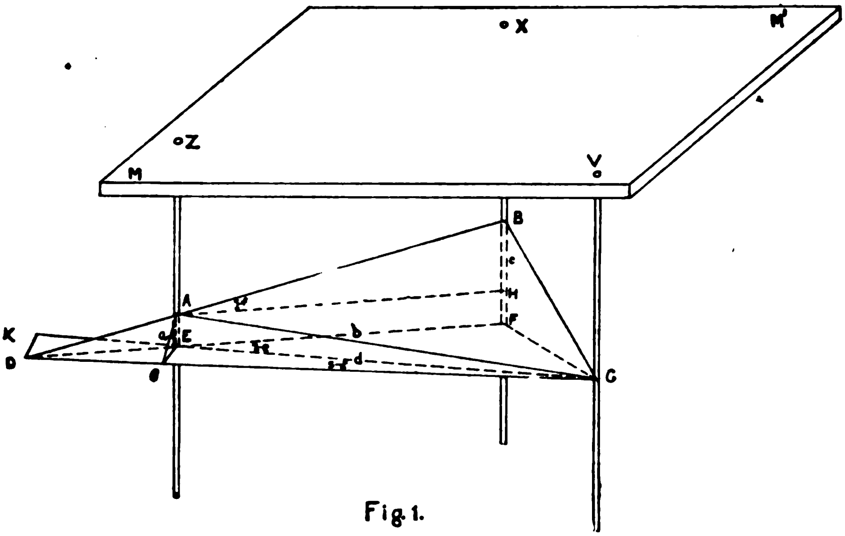


Fig. 1.

Let *MM'* (Fig. 1) represent the surface of the ground, and *V*, *Z* and *X* be three vertical drill holes which encounter the same stratum of rock at points *C*, *A*, and *B* respectively. Let point *C* have the lowest sea-level elevation, point *B* the highest, and point *A* intermediate between the two. Draw *AB*, *BC*, and *AC*.

Pass the plane *EFC* through the point *C* perpendicular to the drill holes *Z* and *X*, cutting *Z* at point *E* and *X* at point *F*. Draw *EF*, *EC*, and *FC*. Draw *AH* parallel to *EF*. Extend *AB* until it intersects the plane determined by the points *E*, *F*, and *C* at *D*. Draw *DC;* the bearing of the line *DC* is the strike of the stratum *ABC*, since it is the line of intersection of the plane *ABC* with the horizontal plane *DFC*. The bearing of the line *EC* is known, so to calculate the bearing of the line *DC* it is necessary only to find the angle *ECD*.

Draw *EG* perpendicular to *DC*. Draw *AG*, then angle *AGE* measures the dip of the stratum as it measures the dihedral angle *B-DC-F*, and this dihedral angle is formed by the intersection of the plane of the stratum *DBC* with the horizontal plane *DFC*. Therefore, to find the dip of the stratum it is necessary only to find the angle *AGE*. In the right triangle *A B H*,

---

*Engineering and Mining Journal, July 15, 1916.

AH and BH are known, and angle BAH can be found from the formula: Tan $BAH = BH \div AH$. But angle BAH = angle ADE (alternate interior angles.)

In the right triangle AED, AE and angle ADE are known, and DE can be found from the formula, Cot $ADE = DE \div AE$. In the triangle DEC, DE and EC are known, and the angle $DEC = 180° -$ angle FEC. Since angle FEC is known, angle DEC can be found. We have given, then, an oblique triangle with two sides and the included angle known. From D let fall a perpendicular in the horizontal plane cutting the line EC (extended) at point K. In the triangle DKC,

Tan $ECD = DK \div (KE + EC)$
Sin $(180° - DEC) = DK \div DE$
$DK = DE \sin (180° - DEC)$
but $180° - DEC =$ angle FEC
therefore $DK = DE \sin FEC$

Cos $(180° - DEC) = \cos FEC = KE \div DE$
therefore $KE = DE \cos FEC$
Substituting in Tan $ECD = DK \div (KE + EC)$
Tan $ECD = (DE \sin FEC) \div (DE \cos FEC + EC)$
Substituting knowns for unknowns in the foregoing equation:
Tan $ECD = (AE \cot BAH \sin FEC) \div (AE \cot BAH \cos FEC + EC)$

$$\text{Tan } ECD = \frac{AE \times \dfrac{AH}{BH} \times \sin FEC}{AE \times \dfrac{AH}{BH} \times \cos FEC + EC}$$

In order to simplify the formula, let:

$AE = a$, the difference in elevation between the stratum in hole V at C and in hole Z at A.

AH or $EF = b$, the surveyed distance between holes Z and X.

$BH = c$, the difference in elevation between the stratum in hole Z at A and in hole X at B.

$EC = d$, the surveyed distance between drill holes Z and V.

Angle $FEC = e$, the surveyed horizontal angle at hole Z.

Angle $BAH = f$, the angle included between a line drawn in the plane of the stratum connecting holes Z and X and a line drawn from the point of intersection of this line with hole Z, perpendicular to hole X.

Angle $ECD = S$, the angle to be added to or subtracted from the bearing of the horizontal line connecting holes Z and V to determine the strike of the stratum.

Angle $AGE = D$, the angle of dip of the stratum. Then:

$$\text{Tan } S = \frac{a \times \dfrac{b}{c} \times \sin e}{a \times \dfrac{b}{c} \cos e + d} = \frac{\dfrac{ab \sin e}{c}}{\dfrac{ab \cos e + cd}{c}}$$

$$\text{Tan } S = \frac{ab \sin e}{ab \cos e + cd}$$

the angle to be added to or subtracted from the bearing of the line EC to determine the strike of the stratum.

In the right triangle CEG, EC (d) and angle ECG (S) are known, and EG can be found from the formula $\tan S = EG \div d$. $EG = d \tan S$.

In right triangle AEG, AE (a) and EG ($d \tan S$) are known, and the angle AGE (D) can be found from the formula (for finding the dip of the stratum), $\tan D = a \div (d \tan S)$.

There are two special cases to the foregoing: Case 1, where all three drill holes encounter the stratum at the same sea level elevation, in which case the stratum is level and there is no dip or strike; case 2, where two of the drill holes encounter the stratum at the same sea level elevation, in which case the strike is the bearing of the horizontal line connecting these two drill holes and the dip can be calculated.

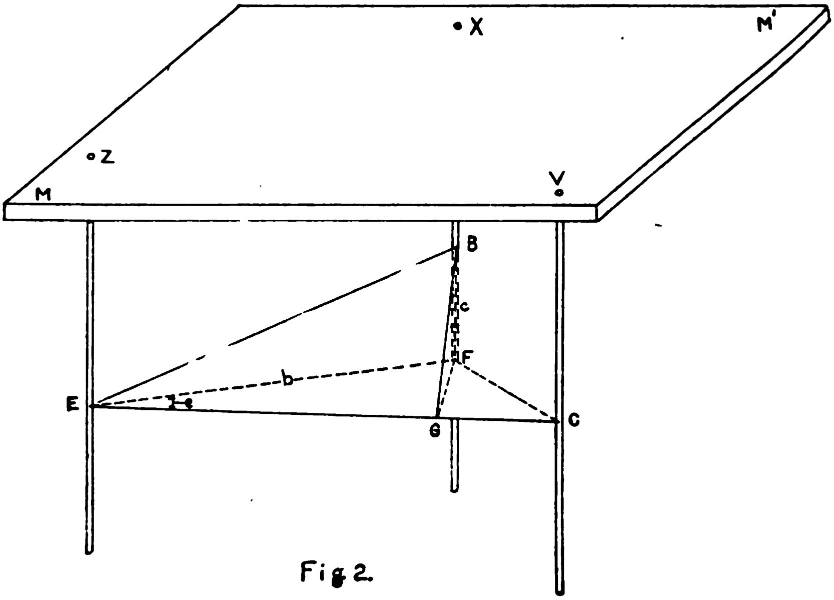


Fig 2.

Let MM^1 (Fig. 2) represent the surface of the ground, and let the vertical drill holes V and Z encounter the same stratum of rock at point C and E, which have the same sea level elevation, also let drill hole X encounter the stratum at point B, which has either a higher or lower sea level elevation than points E and C.

Pass the plane EFC through the line EC perpendicularly to drill hole Z and cutting hole X at point F. Draw FG perpendicular to line EC and connect B and G. The bearing of the line EC is the strike of the stratum. The angle BGF (D) is the angle of dip as it measures the dihedral angle B-EC-F, and this dihedral angle is formed by the intersection of the plane of the stratum EBC with the horizontal plane EFC.

In the right triangle EGF angle e and the hypotenuse b are known, and leg FG can be found from the formula $\sin e = FG \div b$. $FG = b \sin e$.

In the right triangle BFG, c and FG are known, and angle BGF (D) *can be found from the formula,* $\tan D = c \div (b \sin e)$ which is the formula for finding the dip of the stratum.

COST OF DRILLING WELLS IN TEXAS AND OKLAHOMA.

Compiled by

Oklahoma Geological Survey.

GENERAL STATEMENT.

The following figures on the cost of drilling are given with the hope that they will be of some assistance to citizens of the State who are contemplating drilling. In so far as possible, prices are given for February 22, 1916; June 23, 1917, and July 27, 1917. These prices show a great increase in the price of drilling and drilling material.

CONTRACT DRILLING.

In regions where the formations are generally familiar to the drillers, the contractor makes a special rate per foot with the rig, fuel, casing, water, and transportation furnished by the producer. Where the formations are not known, or for deepening old wells, a general rate per day is charged, with the same materials furnished.

The following table shows the rate for drilling in various fields:

TABLE SHOWING PRICE PER FOOT FOR DRILLING OIL AND GAS WELLS IN VARIOUS FIELDS.

FIELD.	RATE.		
	February 22, 1916.	June 23, 1917.	July 27, 1917.
To shallow sand in Bartlesville, Nowata and Tulsa districts	$0.80 to $1.00	$1.00 to $1.25	$1.25
To Layton sand in Cushing field	1.35	1.50	2.50
To Bartlesville sand in Cushing field, northeast	1.50	2.00	3.50
To Bartlesville sand in Cushing field, southeast	2.00	2.25	3.50—4.00
To the shallow sands in Newkirk, Ponca City and Garber fields	1.50	1.50	1.50
To the deeper sands in Newkirk and Ponca City fields	2.50	3.50 (above 2,500 ft.)	3.50—4.00
Healdton field	1.40 to 1.50	1.75	1.75
Electra and Burkburnett to 1,200-foot depth	2.00		
Electra and Burkburnett to 2,100-foot depth	8.50	Note.—Price for rotary drilling to 2,000 feet is $3.00.	
Electra and Burkburnett to more than 2,500-foot depth	5.00		

The regular charge for work by the day, February 22, 1917, was $50 for a double shift. This held good throughout the above fields. All wildcat propositions some distance (50 miles or more) from any of the above-mentioned fields demanded $3.00 per foot.

AMOUNT OF CASING USED IN THE WELLS.

e following table shows the amount of casing used in wells various fields

Field.	Depth.	Size of Casing.	Weight.
field in ast Oklahoma.	1,000 ft. To bottom	8 in. 6 in.	28 lbs. 24 lbs.
field.	400 ft.	10 in.	40 lbs.
	600 ft.	8 in.	28 lbs.
	1,000 ft.	6 5/8 in.	24 lbs.
	1,200 ft.	5 3/16 in.	
d of the shing field.	190-400 ft.	15 1/2 in.	70 lbs.
	400-800 ft.	12 1/2 in.	50 lbs.
	800-1,400 ft.	10 in.	40 lbs.
	1,200-2,000 ft.	8 in.	28 lbs.
	2,000-2,800 ft.	6 5/8 in.	24 lbs.
	2,400-3,000 ft.	5 3/16 in. liner	
nd of the ishing field.	200-300 ft.	15 1/2 in.	70 lbs.
	400-500 ft.	12 1/2 in.	50 lbs.
	1,000 ft.	10 in.	40 lbs.
	1,600 ft.	8 in.	28 lbs.
	2,200-2,300 ft.	6 5/8 in.	24 lbs.
	To bottom	5 3/16 in. liner	
st of shing field.	500-600 ft.	15 1/2 in.	70 lbs.
	800 ft.	12 1/2 in.	50 lbs.
	1,100-1,360 ft.	10 in.	40 lbs.
	1,800-2,000 ft.	8 in.	28 lbs.
	2,800 ft.	6 5/6 in.	24 lbs.
	2,900 ft.	5 3/16 in. liner	

Field.	Depth.	Size of Casing.	Weight.
st Texas gion.* um amount.	80-100 ft.	15 1/2 in.	70 lbs.
	400 ft.	12 1/2 in.	50 lbs.
	1,000 ft.	10 in.	40 (or 28) lbs.
	1,500 ft.	8 in.	20 lbs.
	1,800 ft.	6 5/8 in.	17 lbs.
	2,200 ft. (?)	5 3/16 in. liner	
st Texas gion.* um amount.	800 ft.	10 in.	28 lbs.
	1,500 ft.	8 in.	20 lbs.
	2,000 ft.	6 5/8 in.	17 lbs.

e.—Some rotary drilling in this district, consequently the variation in of casing, the rotary method using only about one-half as much as the ill method.

PRICE OF CASING.

At the present time (July, 1917) any quoted price on casing holds good for only a few days at a time. The standard length of casing is 20 feet. The tables below give prices of casing at Tulsa, Oklahoma, and Wichita Falls, Texas. There is a 5 per cent to 10 per cent cut on carload lots. All measurements given below are inside diameter.

Price of Casing F. O. B. Tulsa.

Size.	Weight.	Price per foot.		
		Feb. 22, 1916.	June 23, 1917.	July 27, 1917.
15 1/2 in.	70 lbs.	$2.75	$5.34	$7.00
12 1/2 in.	50 lbs.	1.31	3.33	5.00
10 in.	35 lbs.	1.21	2.63	3.25
8 1/4 in.	38 lbs.	0.94	2.05	2.40
6 5/8 in.	20 lbs.	0.65	1.62	2.10
5 3/16 in.	17 lbs.	0.48	1.02	1.70

Price of Casing F. O. B. Wichita Falls, Texas.

Size.	Weight.	Price per foot.		
		Mar. 2, 1916.	June 23,* 1917.	July 27, 1917.
15 1/2 in.	70 lbs.	$3.53	$5.29	$5.34
12 1/2 in.	50 lbs.	2.15	3.27	3.43
10 in.	28 lbs.	1.12	----	----
8 1/4 in.	20 lbs.	0.76¼	1.24	1.30
6 5/8 in.	17 lbs.	0.64½	1.12	1.21
5 3/16 in.	13 lbs.	0.50½	0.98	1.02

*Estimated.

HAUL.

Throughout Oklahoma the cost of teams per day ranges from $5.00 to $6.00. Possibly in the Healdton field it might be safe to count on a team for $5.00, while elsewhere it would not. In Texas the cost per team per day ranges from $5.00 to $8.00. An average team is capable of hauling about 3,500 pounds per load. A 15-mile haul is a full day's work, especially in northern Oklahoma, where the roads are usually poor. Texas and Carter County, Oklahoma, roads are good and a team might be expected to haul more or cover a little more distance. The above figures give an average rate of 23 cents per ton per mile. The Gypsy Oil

Company has reduced its cost of haul to about one-fourth of the original cost by the use of tractor engines.

The following figures give the average number of loads necessary for moving the equipment of a drill: 23 loads for engine, boiler, tools, etc.; 18 to 20 loads for lumber; and 5 loads for casing. The casing could be grouped into loads as follows: 2 joints (20-foot lengths) of 15½-inch; 3 joints of 12-inch; 5 joints of 10-inch; 7 joints of 8-inch; and 9 joints of 6⅝-inch material.

TIMBER.

An ordinary 72- to 80-foot rig uses:

13,000 feet (board measure) pine @ $37 per M	$481
8,000 feet (board measure) rig timbers (oak) @ $50 per M	400
Labor on a new rig	300
Total	$1,181

Figuring a 15-mile round-trip haul, at the above figures, the equipment could be hauled and an 80-foot rig erected for approximately $1,500.

FUEL.

In the Cushing field and generally in northern Oklahoma, as well as in the Healdton field, gas is furnished a boiler for a standard rig at $5.00 per double shift. The amount of gas consumed by one boiler for 24 hours is 75,000 to 100,000 cubic feet.

In the Potato Hills region of Oklahoma wood was used. About 2 cords of this wood was consumed in 24 hours by one boiler.

In the Texas fields oil is the fuel used and the amount necessary for 24 hours is about 12 or 15 barrels.

Coal is generally considered out of the question in Oklahoma or Texas. However, the amount necessary to run a boiler 24 hours is about 2.5 tons of bituminous coal.

LENGTH OF TIME REQUIRED TO COMPLETE A WELL.

About 30 days is required to complete a well in the shallow fields of northeastern Oklahoma; 75 to 100 days in the Cushing field; 125 to 135 days in the Blackwell, or fields west of the Cushing; 18½ days in the Healdton field; 30 to 45 days in northwest Texas with rotary drill, or 60 to 75 days with cable tools.

WATER.

Water conditions vary considerably in each of the fields, so that only a general approximation can be made. Some water is pumped from shallow bored wells; some collected in surface reservoirs; some pumped from streams or springs; and some furnished by contract from sources most available. The average cost of a tank of water (250 barrels) is $7.00 or $8.00.

In the Cushing filed 150 to 250 barrels of water are necessary for each 24 hours of drilling; in the Healdton field 150 to 200 barrels; and in northern Texas more than 150 barrels.

OKLAHOMA GEOLOGICAL SURVEY
Chas. N. Gould, Director

Circular No. 9

THE SYCAMORE LIMESTONE

By
C. L. Cooper

NORMAN
DECEMBER, 1926

CONTENTS

Page

INTRODUCTION 5
- Purpose 5
- Literature 5
- Acknowledgments 8

LOCATION AND THICKNESS 8
- Description of stations 10

LITHOLOGY 14
- Megascopic 14
- Heavy mineral determinations 16

PALEONTOLOGY 19
- Description of species 21

CONCLUSIONS 22

ILLUSTRATIONS

PLATE
- I. A typical exposure of Sycamore limestone 14
- II. Shale parting in the Sycamore limestone 23
- III. Close view showing bedding and jointing planes 26
- IV. Photomicrographs of mineral grains 27

FIGURE
- 1. Map of Oklahoma, showing area covered by this report 8
- 2. Pre-Pennsylvanian rocks on the Mansville anticline 11
- 3. Apparatus used in heavy mineral determinations 17
- 4. Graph of heavy mineral content 19

TABLES

- Paleozoic section in the Arbuckle Mountains 7
- Section of Sycamore limestone, near Mansville, Oklahoma 10
- Approximate chemical analysis of the Sycamore limestone 16
- Mineral content calculated from chemical analysis 16
- Fossils in the Sycamore limestone 20

THE SYCAMORE LIMESTONE

INTRODUCTION

PURPOSE

Very little work of a detailed nature has been done on this formation, consequently there are some problems concerning it which have been unsolved. First of these problems is a detailed lithologic description, and second, is the placing of the formation in its proper position in the columnar section. Dr. Chas. N. Gould[1] states:

> "The age of the Sycamore has been a matter of controversy and it is altogether possible that the last word on the subject has not been written. * * * Following the preponderance of opinion, the Sycamore is here assigned to the basal part of the Mississippian and correlated with the Boone limestone."

Since the above quotation is the last that has been written, it is readily seen that there is much to be done on the subject of the age and correlation of the Sycamore limestone.

LITERATURE

Only a small amount of information has been published on the Sycamore limestone. Five articles are found in the literature giving as much as a paragraph to the description of this formation, and in only two of these have the writers done anything that might be called detailed work. J. A. Taff[2] named the formation in 1903 in his report on the Tishomingo Quadrangle. The type locality, from which the formation is named, is located in T. 3 S., R. 4 E., where the limestone is crossed by Sycamore Creek.

Taff describes the formation as being "lentils and wedges," because of its increasing thickness westward while to the east it thins, and at the border of the quadrangle along Buckhorn Creek Valley it is about 50 feet thick. In the vicinity of Gilsonite near the northwest corner of the quadrangle, a thin, somewhat cherty limestone occurs at the horizon of the Sycamore. In a later publication Taff[3] describes the limestone as outcropping very near the base of the Carboniferous throughout the southern side of the Arbuckle uplift. It also occurs on the north side of the Arbuckle Mountains, and extends eastward into the central part of the uplift, almost to the granite. Near the extreme western end of the Arbuckle Mountains he gives the for-

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1. Gould, Chas. N., Index to the Stratigraphy of Oklahoma: Oklahoma Geol. Survey Bull. 35, p. 23, 1925.
2. Taff, J. A., U. S. Geol. Survey, Geologic Atlas, Tishomingo Folio, (No. 98) p. 5, 1903.
3. Taff, J. A., U. S. Geol. Survey, Prof. Paper 31, pp. 13, 32, 33, and 48, 1904.

mation a thickness of nearly 200 feet, and near the central part of the Arbuckle uplift a thickness of about 50 feet, thinning eastward near the granite in the northeastern corner of T. 2 S., R. 3 E. Elsewhere in the uplift, towards the northeast, it is absent or represented by local thin siliceous limestone strata. At the top of the Devonian in the same report, the above writer describes the occurrence of the Sycamore in the Criner Hills as follows:

"The relation of the Pennsylvanian to the older rocks is essentially the same as in the Arbuckle Mountains as far as could be determined by a general survey. The Sycamore limestone and the Caney shale of the Mississippian occur infolded with older rocks and it seems evident that in this area as elsewhere in the Arbuckle Mountain region, active disturbances of the rocks did not occur until about mid-Carboniferous time."

The next man to do detailed work on the Sycamore was Geo. D. Morgan[4], who describes the formation in the Stonewall Quadrangle. The Sycamore limestone had not been previously recognized in the Stonewall Quadrangle until Morgan's work in that area. Its occurrence is now clearly established on the Lawrence uplift, where the outcrop is continuous, forming an excellent key horizon. Morgan also finds that the formation in this area has thinned greatly, averaging less than five feet in thickness. Its lithologic character is almost identical with that occurring in the main Arbuckle Mountain uplift. However, in contrast with other localities, the formation in the Stonewall Quadrangle contains a number of fossils, and Morgan's discovery of this fauna is the first recorded from the Sycamore limestone. Due to the similarity of the fauna beneath and above the Sycamore and the extreme thinning of the formation in that area, Morgan thinks that the deposition was continued from late Woodford throughout Sycamore and into early Caney times. The list of fossils collected by Morgan is as follows:

Menophyllum sp.
Polypora sp.
Productella n. sp.
Chonetes geniculatus
Ambocoelia levicula
Brachythyris n. sp. (?)
Brachythyris peculiaris
Martinia n. sp.
Composita buckleyi
Proetus (2 species)
Ostracoda (smooth)

---

[4] Morgan, Geo. D., Geology of the Stonewall Quadrangle, Oklahoma: Bur Geology, Bull. 2, pp. 48-50, 1924.

This list was sent to Prof. Schuchert of Yale University who stated, in a personal communication to Mr. Morgan, that although guide forms were lacking, he is satisfied that the fauna is Kinderhook. In view of the Moorefield and Fayetteville-like fauna of adjacent portions of the Caney and Woodford formations, Prof. Schuchert's interpretation of the Sycamore fauna suggests a condition which is difficult to explain. That is, it appears that what might be normally considered as pre-Boone fauna is included in a formation which occurs between two other formations both of which carry a fauna which might be normally considered as post-Boone. Mr. Morgan, regardless of Prof. Schuchert's Kinderhook-like interpretation of the Sycamore fauna, concludes that: "* * * the formation together with the upper portion of the Woodford and the lower portion of the Caney, is partially equivalent to the Moorefield shale, the Batesville sandstone and the Fayetteville shale of Arkansas."

Other writers mentioning the Sycamore limestone in the literature are Reeds[5], Hutchison[6], Wallace[7], and Gould[8].

The following section of Paleozoic rocks in the Arbuckle Mountains shows the relation of the Sycamore limestone to other formations in that region:

Paleozoic Section in the Arbuckle Mountains

(After U. S. Geol. Survey)

		Feet
	?	
Mississippian	Caney shale	800-1600
	SYCAMORE LIMESTONE	0-200
	?	
Devonian	Woodford chert	600-650
	Bois d'Arc limestone	0-90
	Haragan shale	0-166
Silurian	Henryhouse shale	0-223
	Chimneyhill limestone	0-53
Ordovician	Sylvan shale	50-300
	Viola limestone	500-800
	Simpson formation	1200-2000
Cambrian	Arbuckle limestone	4000-8000
	Reagan sandstone	0-500
	Average total	10,866

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[5] **Reeds, Chester A.**, A report on the Geological and Mineral Resources of the Arbuckle Mountains, Oklahoma: Okla. Geol. Survey, Bull. 3, p. 41, 1910.

[6] **Hutchison, L. L.**, Preliminary report on the Rock Asphalt, Asphaltite, Petroleum and Natural Gas in Oklahoma: Okla. Geol. Survey, Bull. 2, p. 15, 1911.

[7] **Wallace, B. Franklin**, The Geology and Economic Value of the Wapanucka Limestone of Oklahoma: Okla. Geol. Survey, Bull. 23, pp. 28-29, 1915.

[8] Gould, Chas. N., op. cit.

ACKNOWLEDGMENTS

The writer is indebted to Dr. Charles E. Decker of the University of Oklahoma, under whose supervision this work has been done. Whatever merit this article may have is due in a large measure to his interest and helpful criticism.

Dr. George H. Girty of the U. S. Geological Survey has kindly checked the fossils collected, and has given many helpful and pertinent suggestions concerning their identification.

The map accompanying this report is the compilation of of material published by the U. S. Geological Survey, the Oklahoma Geological Survey, and Morgan's report on the Geology of the Stonewall Quadrangle, which has been supplemented by field work done by the author.

LOCATION AND THICKNESS

The outcrops of the Sycamore limestone are found in parts of Pontotoc, Murray, Carter, Johnston, and Marshall counties. The principal areas are associated with the Arbuckle Mountain uplift, where the longest and most continuous outcrops flank the Arbuckle anticline (See map). The formation is brought to the surface by faulting at the Criner Hill uplift, T. 5 S., R. 1 E., in secs. 22 and 23, T. 1 S., R. 3 E., in sec. 4, T. 4 S., R. 5 E., and sec. 34, T. 2 S., R. 3 E. In Pontotoc County the formation is found in two outcrops, the first occurring in the southern part of T. 3 N., R. 6 E., extending southeast into the northeastern part of T. 2 N., R. 6 E.; the second from the center of T. 1 N., R. 7 E., to the southeast corner of the township ending in the northeast corner of sec. 1, T. 1 S., R. 7 E. This is the thinnest

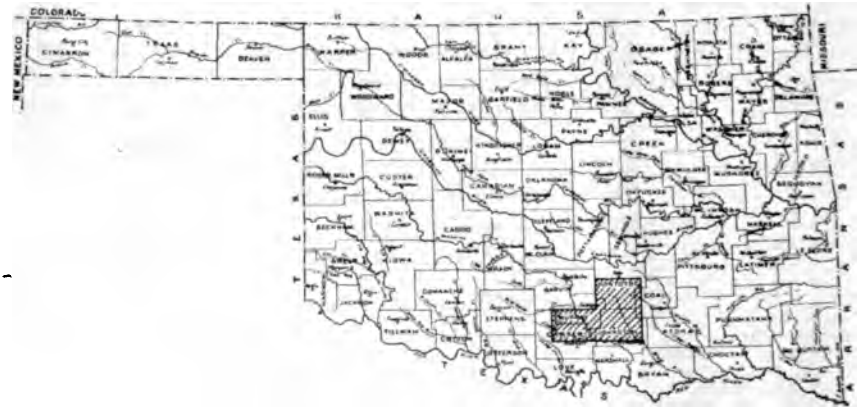

Figure 1. Map of Oklahoma, showing area covered by this report.

ıase of the formation found, and is on the average less than
'e feet thick. However, fossils are abundant in these two ex-
sures. In Murray County the formation borders the Washita
ver on the north, beginning in the NE. ¼ sec. 30, T. 2 S.,
3 E., extending northwest bordering the northeast flank of
ɔugherty Basin, until it is lost in sec. 2, T. 1 S., R. 2 E. The
ickness here is more than 100 feet. It is also found at the
se of the slope of Vine's Dome, secs. 28, 33, and 34, T. 1 S.,
2 E. Due to the fact that the Woodford-Sycamore contact
uld not be located at this place, the thickness is estimated at
0-150 feet. On the opposite flank of the basin on the south-
ɘst side of the river, it is found as a disconnected outcrop from
e southeast corner of sec. 3, T. 2 S., R. 2 E., thence northwest
the west side of sec. 13, T. 1 S., R. 2 E., the formation is 140
ɘt thick.

Just southeast of Davis and northeast of Dougherty, there
a long sinuous outcrop, less than 50 feet thick and thinning
stward, beginning in sec. 2, T. 2 S., R. 3 E., extending north-
st and ending in sec. 26, T. 1 S., R. 2 E. This outcrop is
ughly the shape of a figure nine and occurs in the northwest-
n end of the Tishomingo anticline. North of this outcrop is
und the small up-faulted portion mentioned above, which is ex-
sed as a thin cherty limestone (T. 2 S., R. 3 E., northwest of
ıckhorn). The formation enters Carter County in sec. 13, T. 3
R. 3 E., and extends northwest to sec. 4 of the same township,
ıere it is concealed by Washita River sediment. It is again
ːked up in sec. 6 of the same township, and extends roughly
ɘstward through Tps. 2 and 3 S., and Rs. 2 E., 1 E. and 1 W.,
the town of Woodford, where it again trends northwest and
ds in sec. 12, T. 2 S., R. 2 W., where it is covered by Permian
diments. The formation is nearly 200 feet thick west of Wood-
rd, thinning eastward until in the railroad cut it is 140-157
ɘt thick. In Johnston County the formation runs southeast
ɔm sec. 18, T. 3 S., R. 4 E., across the township and leaves the
ınty in the southeast corner of sec. 36, and thence across secs.
and 6, T. 4 S., R. 5 E., ending just across the line of sec. 4,
ıere it is terminated by a fault.

This long outcrop, which is continuous for nearly forty
les, forms a part of the southern limb of the Arbuckle anti-
ne. It is not exposed on the northern limb of this anticline
d it is thought the long fault immediately north of the out-
ɔp in eastern Carter and western Johnston counties, has con-
aled the formation at this place. That this is probable, is
own by the fact that small patches of the Sycamore are
ought up and exposed on the surface by branching faults off

this main fault in sec. 4, T. 4 S., R. 5 E., and in secs. 33 and 34, T. 2 S., R. 3 E.

In the Crimer Hills area, T. 5 S., R. 1 E., the formation is exposed in secs. 10, 15, and 36. The exposures are here brought to the surface by a number of complex faults which are found in that region.

In northern Marshall County there occurs an inlier of Paleozoic sediments surrounded by Cretaceous rocks (Trinity sandstone). The older rocks are exposed in the Valley of Turkey Creek in sec. 3, T. 5 S., R. 4 E., and secs. 34 and 35, T. 4 S., R. 4 E. This inlier was first noted by Mr. C. W. Tomlinson[9] while working in that area. (See Fig. 2).

The following is a section of Sycamore limestone given in Mr. Tomlinson's paper:

Section of Sycamore Limestone, near Mannsville, Okla.

	Feet
Limestone, dense, drab, massive, blocky, very finely crystalline: in beds 2 inches to 1 foot thick, no fossils found	45
Concealed interval	35
Limestone, same as above	9
Concealed interval	3
Limestone, dense, drab, blocky, very finely crystalline, no fossils found	10
Shale, greenish, calcareous	2
Sandstone, white, calcareous, medium-coarse grained	1
	105

From the above section it would seem that the Sycamore is at least 100 feet thick at this place. The occurrence is on the south limb of the anticline as shown in Figure 2. As to the structure, Mr. Tomlinson states that in the northernmost outcrops there is a distinct semi-circular swing of the strike around the nose of an anticline which is plunging steeply to the southwest, so that the extreme north end of the Viola exposures the strike is due northeast. These pre-Pennsylvanian outcrops on Turkey Creek occur exactly in the trend of a plunging anticline exposed in the Pennsylvanian rocks (Glenn formation) four or five miles to the northwest.

DESCRIPTION OF STATIONS

Station No. 1. N. ½, NE. ¼, sec. 30, T. 1 S., R. 2 E. Location near Davis farm where road crosses creek. Thickness 140

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[9] Tomlinson, C. W., Buried Hills near Mannsville, Oklahoma: Bull. Am. Assn. Pet. Geol. Vol. 10, p. 139, 1926.

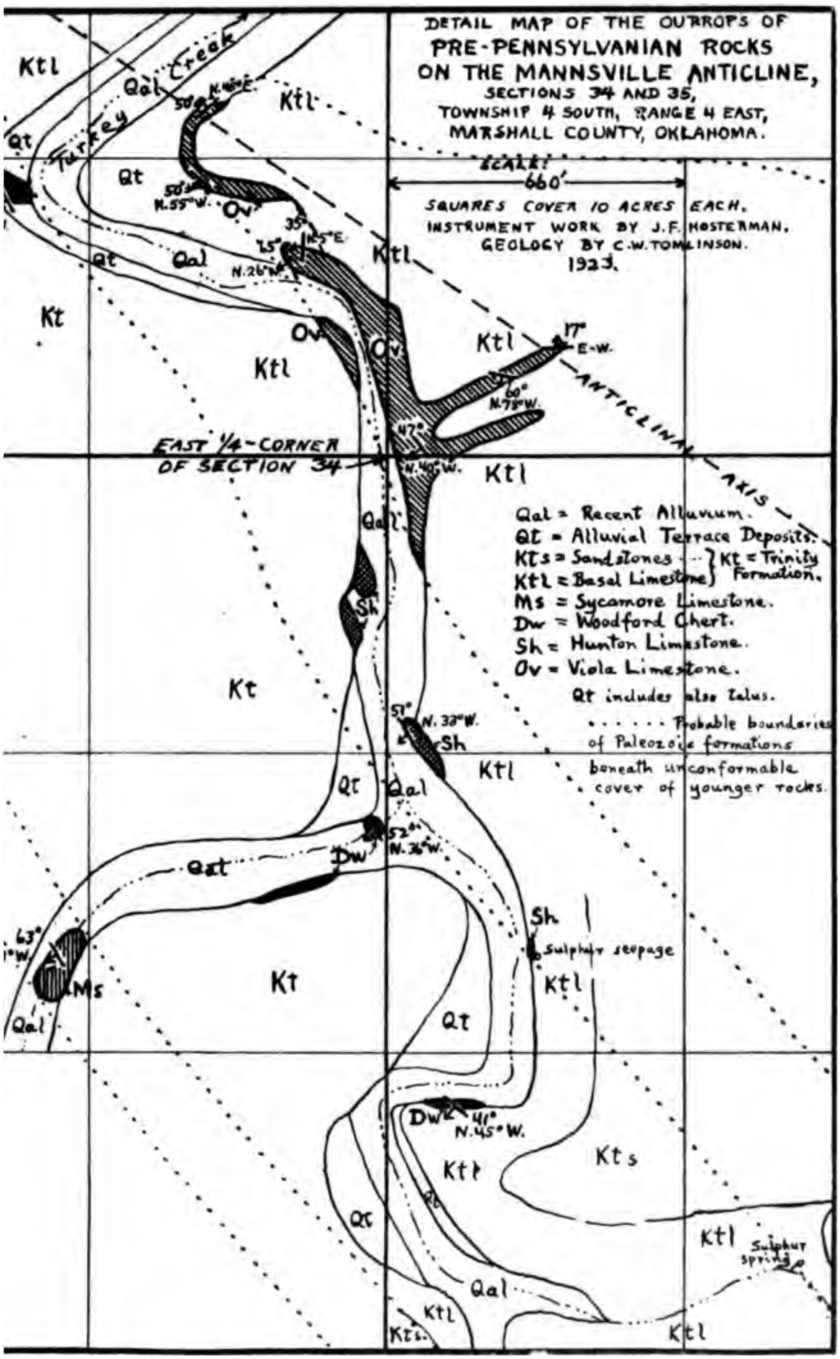

Figure 2. Pre-Pennsylvanian rocks on the Mansville anticline.
(Courtesy Am. Assoc. Pet. Geol., Geology by C. W. Tomlinson)

feet. Dip vertical. Strike approximately N. 45° W. Rock massive, weathered to a dull yellow. Contact at bottom found with Woodford chert member, but no contact found at the top due to the weathering of the Caney shale. Uppermost beds exposed in the creek probably indicate where the overlying Caney shale comes in. The formation is much fractured, breaking into rectangular blocks. In places the fractures are filled with veins of calcite, which seems to be concentrated along particular beds, where the limestone was pulled apart by tensional stress at the time of the folding. The formation appears to be uniform throughout, except in a few places which are thinly stratified. indicating a higher amount of clayey material than is found in other places. The formation is overlain locally by one of the latest beds of Franks conglomerate which makes a contact with the older formations below it that is an uneven, approximately horizontal surface. The conglomerate consists mainly of limestone boulders ranging up to two feet in diameter, with numerous boulders of Colbert porphyry of the East Timbered Hills. The porphyry boulders in the conglomerate show that the overlying conglomerate was not deposited until the porphyry deposit was exposed to erosion at the end of Pennsylvanian or the beginning of Permian time. Samples were taken at about 10 foot intervals from the base upward.

Station No. 2. Near center of NE. ¼, sec. 12, T. 2 S., R. 2 E. The Caney shale is found along the bed of a small creek at the east end of Main Street of Dougherty. On following the bed of the creek northeast some 200 feet, the Sycamore is encountered in the stream bed and on the hillside to the right and left of the stream. The thickness is estimated at 140-150 feet, with the strike almost northwest-southeast. Dip 40 to 45 degrees to the southwest and the hill is a dip slope. On going up the hill the contact is found between the Caney and the Sycamore just beyond a small bridge over the stream gully. On continuing up the slope the Sycamore is covered by stream deposits, but is found again outcropping about 200 feet from where it is first concealed. The rock is broken up by the characteristic block fracture, and in places the individual blocks project above adjacent blocks which have been removed by erosion, forming a distinct ridges in the stream bed. The distinctive yellow color due to weathering can especially be noted in the stream bed, but on either side the limestone is covered with moss or other growths which give the rock a dirty brown or gray appearance. Calcite veins filling the fractures are not present in this section as in Station No. 1. The formation is very uniform throughout, except for the presence of a fossil lens, being a hard, even, massive rock, very tenaceous, and breaking with a characteristic onchoidal fracture. On following up the dip, a shale is enountered about the 120-130 feet horizon which is about 20 feet n thickness. The contact with the Woodford chert is not found, ut the chert forms the top of the ridge, of which the Sycamore orms the southwestern slope.

Station No. 3. NW. ¼ sec. 2, T. 2 S., R. 2 E., along Davis-Dougherty road which runs on east side of river, at point where oad branches to Vine's Dome. Sycamore found along bed of reek west of road and on hillside of the road where it is in conact with the Woodford chert. Along the creek there is a gap r offset in the formation which is probably due to a fault. The beds have a different attitude on each side of the gap. Dip 50° west, strike N. 10° E. Fossils were collected at the foot of the ast slope of the ridge at what should be near the bottom of the ormation near the contact with the Woodford.

Station No. 4. NE. ¼, sec. 6, T. 3 S., R. 3 E. Formation xposed in railroad cut south of bridge across the Washita River, outh of Crusher. Dip 60° southwest, strike N. 30° E. Heavy bedded, except for two partings of shale. The upper bed of shale nay be Caney, lower one 15 feet thick and is six feet from the op. One small shale parting three inches thick is found about 70 feet from the top of the formation. The shale parting is omposed of alternating layers of black and gray shales. The Sycamore is 157 feet thick at this place, including 140 feet of imestone and 17 feet of shale.

Station No. 5. SW. ¼, sec. 25, T. 2 S., R. 1 W. Section aken 500 yards east of the road running north from the town of Woodford. The Sycamore here forms a prominent ridge running east and west, and consists of alternating layers of massive, blue to brown limestone and brown limy shale. The broad band of shale at Crusher is absent here, but the formation as a whole is much more shaly than has been noted elsewhere. Sampling was started at the base, or as near the base as could be determined (the contact with the Caney shale could not be found) and taken at equal intervals to the top. Two parallel ridges are formed by the Sycamore (on the south) and the Bois d'Arc limestone (on the north), separated by a valley of Woodford chert. The shale phase which forms a valley where the formation is crossed by Cool Creek in NW. ¼, sec. 1, T. 2 S., R. 2 E., is not present at this place.

Station No. 6. SE. ¼, SE. ¼, sec. 18, T. 3 S., R. 4 E. North of the old town of Sylvan, Johnston County, on the north side of road crossing Oil Creek. The Sycamore is almost vertical at this place. The large oil spring, located at this place is in the middle of the Sycamore. Contacts with the Woodford and Caney were found. Shale parting present, about six feet in thickness, about the middle of the formation, and just below the large oil spring.

LITHOLOGY

MEGASCOPIC

The Sycamore limestone has a number of characteristics by which it is easily recognized wherever it occurs. In different places the formation varies considerably in thickness, but it possesses to such a remarkable degree its uniformity of color, texture, jointing and method of weathering, that it makes an excellent key horizon.

The limestone on fresh fracture varies from a distinct slate-blue color to a dirty bluish-brown. On weathering this color changes to a characteristic light brownish-yellow hue, due to the presence of small amounts of iron.

The Sycamore limestone has a dense, even texture, is exceedingly tough, and so hard that often it breaks with a distinct conchoidal fracture. A fresh fractured surface is harsh to the feel, and does not have the flint-like appearance of limestones that are more pure.

PLATE I.

A TYPICAL EXPOSURE OF SYCAMORE LIMESTONE.

The bedding of the formation causes the rock to separate to very distinct layers six inches to two feet, more or less, in ickness. In places, notably east and west of Station No. 4, uth of Crusher, and at Station No. 2, east of Dougherty, there a distinct shale parting 6 to 20 feet in thickness, almost in e center of the limestone. At Crusher this shale is an alter- ıting bluish-black and gray shale, somewhat fissile, separated to thin sheets. This shale is soft and weathers easily, as evi- nced by a small valley where Cool Creek crosses the formation ɜst of Station No. 4. West toward Woodford in northeastern ırter County, this shale parting is absent, so this shale is a nticular mass occurring within the formation. Just north of oodford there are a number of horizons in the Sycamore where e formation is apparently a very shaly lime. However, the ale is not present as a distinct member, as in the occurrences rther east, but is included with the layers of the hard, bluish nestone, which is characteristic of the other exposures. In her words, in this special area the limestone itself has graded to a rock that seems to be for the most part a limy shale.

In the Stonewall quadrangle the formation does not reach arly the thickness found in other exposures. In this area it s been observed to have a thickness of not more than five feet, th a probable average of about two feet. In comparing this ickness with other exposures it might be suspected that the hologic character of this outcrop would be entirely different; t the formation here is still a hard, tough, slate-blue limestone, ɜathering to the characteristic bright yellow hue.

At Station No. 6 on Oil Creek, the shale parting near the nter of the formation is extremely gritty, thinner (6 feet ick) and somewhat harder and consequently more resistant an the other occurrences noted. At this place a large oil ring, from which the creek is named, is located at the top of is shale parting.

At Station No. 2, east of Dougherty, the shale near the nter of the limestone is very bluish in color and extremely sile, giving it the appearance characteristic of much of the ıney shales. The shale at this place reaches a thickness of 20 ɜt.

The formation is broken by two sets of joints and a pri- ıry plane of parting along the bedding plane which separates e limestone into layers, 18 inches more or less in thickness. ie two sets of secondary joints are at right angles to each her, one normal to the bedding and the other at an angle to the dding.

Approximate Chemical Analysis of the Sycamore Limestone[10]

	Percent	
	114	115
SiO_2	40.85	39.03
Al_2O_3	3.48	3.48
Fe_2O_3	0.43	0.19
FeO	0.74	1.01
MgO	1.02	1.15
CaO	20.09	28.92
H_2O	0.23	0.25
TiO	0.266	0.266
CO_2	23.89	24.40
MnO	0.01	0.01
	99.006	98.716

Note: No. 114, 65 feet thick above shale parting, one and one half miles south of Crusher, south of railroad bridge over Washita River, in NW. ¼, sec. 6, T. 3 S., R. 3 E., in Carter County. Alkalies not determined.

No. 115, same as 114, except the limestone is 56 feet thick and lies below shale parting. Alkalies not determined.

Mineral Content Calculated from Chemical Analysis

	Percent	
	114	115
Quartz	26.760	34.930
Kaolin	7.570	7.590
Calcite	47.420	48.550
Dolomite	6.010	6.780
Iron Oxides	1.170	1.200
Rutile	0.266	0.266
	99.196	99.316

The above table shows the minerals making up the Sycamore as calculated from Shead's analyses. The striking feature brought out is the large amount of quartz contained in the formation. That a limestone, appearing quite pure on casual examination, should contain almost 45 per cent quartz and clay, is very unusual. Because of this, a number of thin sections and heavy mineral determinations have been made, the results of which are discussed in the following paragraphs.

HEAVY MINERAL DETERMINATIONS

The sixteen samples secured at Station No. 1 on Honey Creek have been used in the heavy mineral determinations because the formation as exposed at that point represents a typical exposure of the Sycamore. As already mentioned in the description of stations, samples were taken at equal intervals from the bottom to the top of the formation. These samples were crushed in a mechanical crusher almost to a fine powder. Weighed samples of 200 grams each were digested ı hydrochloric acid which removed all of the calcium carbon- The samples were then washed free from acid and shale, ing the sand and heavy minerals remaining, which, after ng, were again weighed. The results of this second weigh- show a sand and heavy mineral content ranging from 3.6 1.0 per cent, with a total average of 12.6 per cent. There o regular variation in the percentage, sample No. 8 being highest and No. 16 the lowest in the amount of sand.

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[10] Shead, A. C., Physical and Chemical Analyses of Oklahoma Mineral Raw Material. Unpublished manuscript.

After the second weighing a small amount of the dry sam- was treated for its heavy mineral content. The heavy liquid l for the separation was bromoform (sp. gr. 2.8), which ts such minerals as quartz and feldspar, and allows the heavy erals such as magnetite, zircon, rutile, garnet, etc., to sink. apparatus used is shown in Figure 3. The procedure is ollows:

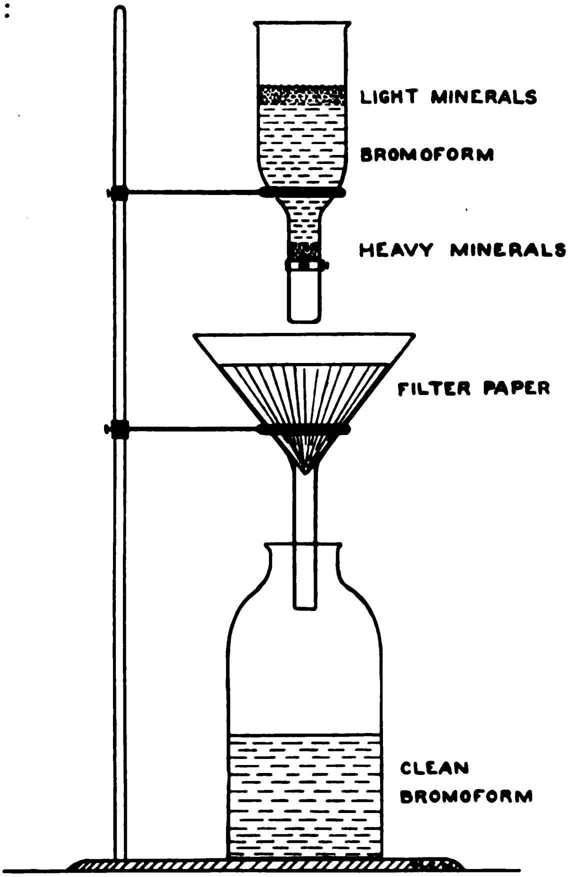

Figure 3. Apparatus used in heavy mineral determinations.

The bromoform is poured into the upper vessel as carefully as possible to eliminate the formation of vertical currents which will carry the light as well as the heavy minerals to the bottom. The sample to be treated is then sprinkled lightly on the top of the bromoform, and the minerals having a higher specific gravity than the liquid will sink to the bottom. It is sometimes necessary to agitate the layer of light minerals which accumulates at the top of the liquid so that the heavier minerals will have a chance to fall to the bottom of the vessel. As soon as the separation is complete the heavy minerals may be drawn off through the pet cock into the filter paper in the funnel below, and the bromoform caught in the bottle below the funnel is then ready for use in another determination. An empty bottle is then substituted for the bromoform bottle and the minerals on the filter paper are then washed with benzol to cleanse the material and save the bromoform. These washings should be kept in a bottle used only for this purpose, so that the dissolved bromoform can later be recovered by fractional distillation.

The washed minerals and the filter paper are then placed in a drying oven and when dry are ready for mounting on slides for study under the microscope. The light minerals remaining in the upper vessel are then drawn off onto a second filter paper which has been placed in the funnel. They are washed with benzol in the same manner as the heavy crop, and, if they are to be studied, placed in the drying oven.

If it is not desired to keep the heavy mineral grains for future study, it is not necessary to make a permanent mounting. If future use of the grains is necessary, it is recommended that they be mounted on a glass slide in Canada Balsam.

Using the mineral content calculated from an ultimate analysis of the Sycamore as given on page 16, the limestone shows that the general composition is:

	Per cent
Sand (quartz—heavy minerals)	12.6
Shale	30.7
Limestone (calcite and dolomite)	54.4
Iron oxides	1.2
	98.9

In the above table it is probable that the percentage of sand is low and that of shale is high because of the fineness to which the sample was ground, which broke up some of the quartz fragments to such a degree that they were washed out of the sample with the acid and shaly material.

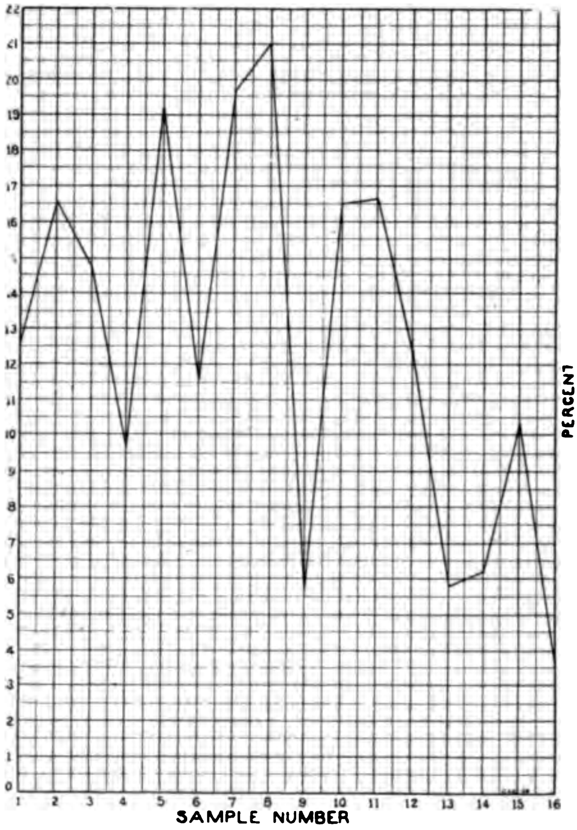

Figure 4. Graph of heavy mineral content.

PALEONTOLOGY

In all there are four horizons in the Sycamore limestone t are found to be fossiliferous, two of which were found by author. Morgan's collection, described in his report on the logy of the Stonewall Quadrangle, was made in the east-tral part of sec. 11, T. 2 N., R. 6 E., and a small collection de by Boone Jones while a student at the University of Okla-a was obtained near the town of Franks. The writer's speci-s were collected from Station No. 2, NE. ¼ sec. 12, T. 2 S., 2 E., and Station No. 3, NW. ¼ sec. 2, T. 2 S., R. 2 E. Only se forms that have never been described in the literature as urring in the Sycamore will be described in this report, and l include Mr. Jones' collection as well as the author's.

Fossils in the Sycamore Limestone

	Collec-tor*	STATION†			
		A	B	2	3
Porifera					
Sponge Spicules			X	X	X
Corals					
Menophyllum sp.	M	X			
Crinoidea					
Stems, several species	A			X	X
Bryozoa					
Fenestella sp.	A			X	
Polypora sp.	M	X			
Brachiopoda					
Composita buckleyi	M	X			
Lingula aff. gorbyi	A				X
Lingulodiscina newberryi	U		X		
Chonetes aff. laevis	A			X	
C. geniculatus	M	X			
Productella n. sp.	M	X			
P. pyxidata	A			X	X
Pustula planiconvexa (?) may be n. sp.	A			X	
Ambocoelia laevicula	M	X			
Martinia n. sp.	M	X			
Pelecypoda					
Caneyella sp.	U		X		
Cephalopoda					
Brachythyris n. sp.	M	X			
B. peculiaris	M	X			
Adelphoceras meslerianum	U		X		
Orthoceras wapanuckense	U		X		
Goniatites choctawensis	UA		X		X
Goniatites aff. choctawensis n. sp. (?)	A		X		X
Trilobita					
Proetus 2 sp.	M	X			
Ostracoda					
Ostracoda smooth	M	X			

*COLLECTOR

M—Morgan, Geo. D., Bur. of Geol. Bull. 2, 1924.

U—Univ. of Okla. coll. made by Boone Jones.

A—Author's collection.

†STATION

A—East-central sec. 11, T. 2 N., R. 6 E.

B—Near town of Franks.

2—NE. ¼ sec. 12, T. 2 S., R. 2 E.

3—NW. ¼ sec. 2, T. 2 S., R. 2 E.

DESCRIPTION OF SPECIES

PORIFERA

A number of sponge spicules collected from several localities.

CRINOIDEA

A number of unidentified stems found in several localities.

BRYOZOA

enestella sp.

Several small fragments collected from Station 2, with mesh uch coarser than *F. tenax*.

BRACHIOPODA

roductella pyxidata[11]

Width greater than length. Hinge line shorter than greatst width of shell. Pedicle valve somewhat flattened and slighty recurved at the cardinal extremities; umbo narrow. Surface f both valves marked with lamellose growth lines; spine-bearng radiating ridges at times present on pedicle valve.

Kinderhook of Illinois and Missouri.

CEPHALOPODA

delphoceras meslerianum[12]

Shell small, discoidal, the largest specimen seen having a iameter of 21 mm. and a thickness of 8 mm. When mature the ross section of the whorls is very high and helmet shaped, deep embracing, so as to largely inclose the preceeding volution and ave a narrow though deep umbilicus. The sculpture of the ature portion consists of rather fine, regular transverse striae, eparated by delicate though strong folds. These are well dened toward the umbilicus, but die out over the venter or become ery faint. The direction of these lines is sinuous—concave over he ventral portion, then convex, with another reentrant curve alf way towards the umbilicus. The venter, which is almost ree from transverse costae, is crossed by extremely fine, deliate revolving striae, so faint that they might be readily overooked even with a moderately strong lens. These revolving triae are continued laterally until they become implicated with he transverse wrinkles or plications, to which, however, they re very subordinate, and they may continue quite to the umilicus. The constrictions are usually deep and occur a quadrant part. They follow the course of the plications in the main, but re strong over the ventral region, where they show a deep sinus. he sutures are those of *Glyphioceras* and *Gastrioceras*.

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[1] North American Index Fossils, Vol. 1, p. 242.

[2] Girty, George H., U. S. Geol. Survey, Bull. 377, p. 66, pl. XII, figs. 1-3e, 1909.

Orthoceras wapanuckense[13]

Shell rather small, long and very gradually tapering. The type specimen has a length of 52 mm. with a diameter above of 5½ mm. and below of 4 mm. The section is circular and the siphuncle central. The septa are moderately far apart, the interseptal distance to any point being to the diameter as 1 is to 1½, varying almost to the ratio of 1 to 2 in young specimens. The largest specimen observed has a diameter of 12 mm. The surface is apparently entirely smooth.

Goniatites choctawensis[14]

Shell is discoidal, broadly and strongly rounded on the abdomen, and flattened laterally, inner volutions entirely concealed by the outer ones; umbilicus small, it's diameter scarcely equal to one-sixth the breadth of the volution; transverse diameter of the volution about equal to the breadth from the dorsal to the ventral side; aperature lunate, much wider than high; surface marked with fine distinct revolving lines, less than the width of the intervals in between, crossed by extremely fine, crowded transverse striae. Septa having but one lateral lobe, on either side; dorsal (ventral) lobe wide as long, divided into two lanceolate branches as an accessory saddle, which is tranuncated and bifid at tip and extends almost to the middle of the lobe; dorsal (ventral) saddle of the same form, but wider and double the length of the branches of the dorsal (ventral) lobe; superior lateral lobe wider than the dorsal (ventral) saddle, and contracted at extremity to an acute point.

Lower Carboniferous, St. Louis-Chester stage (?), Bend formation, Oklahoma.

CONCLUSIONS

The Sycamore formation is a lenticular mass of siliceous limestone occurring above the Woodford chert and below the Caney shale in the area of the Arbuckle Mountain uplift. It varies in thickness from 200 feet at its most western exposure in sec. 12, T. 2 S., R. 2 W., west of the town of Woodford, to less than five feet in thickness in the Stonewall Quadrangle in the eastern part of the mountains. The formation without exception thins everywhere to the east, and is not found east of the exposures mapped in the Stonewall Quadrangle by Morgan. In a number of places, notably on the southern limb of the Arbuckle anticline and on the eastern edge of the Dougherty basin, there is found a distinct shale parting near the middle of the formation. This is well shown in Plate II. This shale is black to gray

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[13] Girty, George H., U. S. Geol. Survey, Bull. 377, p. 44, pl. VI, figs. 11, 12, 1909.

[14] Smith, James P., U. S. Geol. Survey, Mon. XLII, p. 67, 1903.

PLATE II.

SHALE PARTING IN THE SYCAMORE LIMESTONE.

lor and in places somewhat fissile in character, with pyrite ominant heavy mineral, almost to the exclusion of all others e heavy mineral group. The shale is a lenticular mass as n by the absence of this feature in the exposure at Wood- and on the western limb of the Dougherty basin where the ation is crossed by Honey Creek.

With the exception of magnetite, the character of the heavy rals present shows that the sediments which formed the more came very largely from acidic or intermediate igneous s, but whether they came directly from these primary rocks matter of conjecture, as some of the samples show distinctly ded specimens of quartz, magnetite, rutile, and zircon.

Anderson[15] is of the opinion that, "sand grains approach- pherical shape may be of considerable age. No such grains ld be regarded as having been derived from their primary ce, the igneous rocks, during the present cycle of erosion."

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nderson, G. E., Experiments on the rate of wear of sand grains: Jour. of eol., Vol. XXXIV, No. 2, 1926.

In the light of Dr. Anderson's experiments it is evident that the Sycamore is the result of the deposition of material derived from the erosion of an old sedimentary land mass. It is possible that these sediments came from the rocks which once covered the Arbuckle and Wichita Mountains, and which have since been more or less removed and the granite cores exposed. It seems more probable that the source of the sediments is to be found to the west, from the fact that the Sycamore and Caney formations very decidedly thin to the east.

While it is evident that the data seems to place the Sycamore and Caney at a lower level, paleogeographic maps by Schuchert[16] show that the area in which the above formations are found, was covered by epeiric seas throughout Tennessian time, so it would be possible for the Sycamore limestone and the Caney shale to represent the St. Louis stage in this sea, during which sedimentation was quite active as evidenced by the shale parting and the relatively large amount of sand and heavy minerals found in the Sycamore and the large number of sandy and limy lenses found in the Caney, especially the lower part.

After considering all the evidence that is contained in the literature and the writer's observations in the field, it appears that the Sycamore limestone is the result of continuous deposition which occurred throughout upper Woodford, through Sycamore and into Caney time, or in other words, that the deposition was continuous through the upper Devonian and into Mississippian time. Perhaps this statement should be explained since it apparently leaves the lower Mississippian out of consideration. Taff[17] states that the upper part of the Woodford doubtless includes strata corresponding in age with the formations of northern Arkansas and Tennessee, which are believed to be of Kinderhook age, or earliest Carboniferous.

Girty[18] recognizes the fact that, "the Woodford, where the Sycamore is absent, appears to graduate into the overlaying Caney * * * * * and that the Woodford and Caney might be regarded as a local or regional modification of the Caney deposition. As there are few species of invertebrates upon which, if occurring in similar conditions, one would place absolute reliance, it does not seem to me that the Devonian age of the lower Woodford is beyond the reach of future revisions. * * * * * the Woodford and the Caney appear from lithologic and stratigraphic evidence to present continuous sedimentation. The typical Woodford has thus far furnished very little in the way of organic

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[16] Schuchert, Charles. Text-book of Geology, Part II, Revised edition, 1925.

[17] Taff, J. A., U. S. Geol. Survey, Prof. Paper 31, p. 33, 1904.

[18] Girty, George H., U. S. Geol. Survey, Bull. 377, pp. 5-7, 10-11 and 13, 1909.

emains, but such little as we possess does not tend to ally it
ith the Caney." Morgan[19] finds that, "the general lithologic
milarity of the two formations (Caney and Woodford) is so
ose as to make it quite difficult to distinguish between them
here only this criterion is used. * * * * * The fauna of the up-
er part of the formation contains a number of species common
o the Moorefield, Batesville and Fayettville formations of Ar-
ansas, and together with the overlying Sycamore limestone and
e lower part of the subsequent Caney formation, is thought to
e at least partially equivalent to the Arkansas formations."
lthough the base of the Woodford rests uncomfortably on the
nderlying Hunton terrane, there is no observable break with-
n the formation. Gould[20] summarizes the present opinion on
e age of the Woodford as follows: "The Woodford has usually
een considered upper Devonian. It correlates with the Chat-
anooga shale of Oklahoma, Arkansas and Tennessee, and since
e age of this shale is in question, being assigned by some
eologists to the Carboniferous and by others to the Devonian,
he Woodford is here doubtfully assigned to the Devonian."

The above quotations of earlier writers agree wholly on
he point that there is no break of sufficient magnitude between
he Woodford and the Sycamore to represent a time of no de-
osition during lower Mississippian. Some, especially Morgan,
hinks that the faunal evidence tends to show that a part of the
Voodford is basal Carboniferous. The Woodford chert is dis-
inctly marine in lithologic character, although as might be ex-
ected, the fauna is very scarce. Both the Caney and the Syca-
ore carry a distinctly marine fauna, which is so nearly alike,
at the Sycamore may be said to be an early phase of the
ississippian sea in which the Caney was deposited. The exact
e of the Caney has not been satisfactorily determined, nor has
e age of the Moorefield shale, with which the Syamore closely
rees in terms of fauna and time. At present Dr. Girty (in
Personal communication) is of the opinion that the Moorefield
ale is about St. Louis in age, but that the evidence is still
complete and uncertain. Which all means that there is a
eat need for further exhaustive study and careful collecting
the very few localities of the Sycamore that are found to be
ssiliferous. It is hoped that the material thus obtained may
ntain some diagnostic forms which will help to determine the
e of the over and underlying formations, as well as the Syca-
ore.

Morgan, Geo. D., Bur. of Geol., Bull. 2, pp. 44, 46, 1926.

Gould, Chas. N., Okla. Geol. Survey, Bull. 35, p. 22, 1925.

PLATE III.

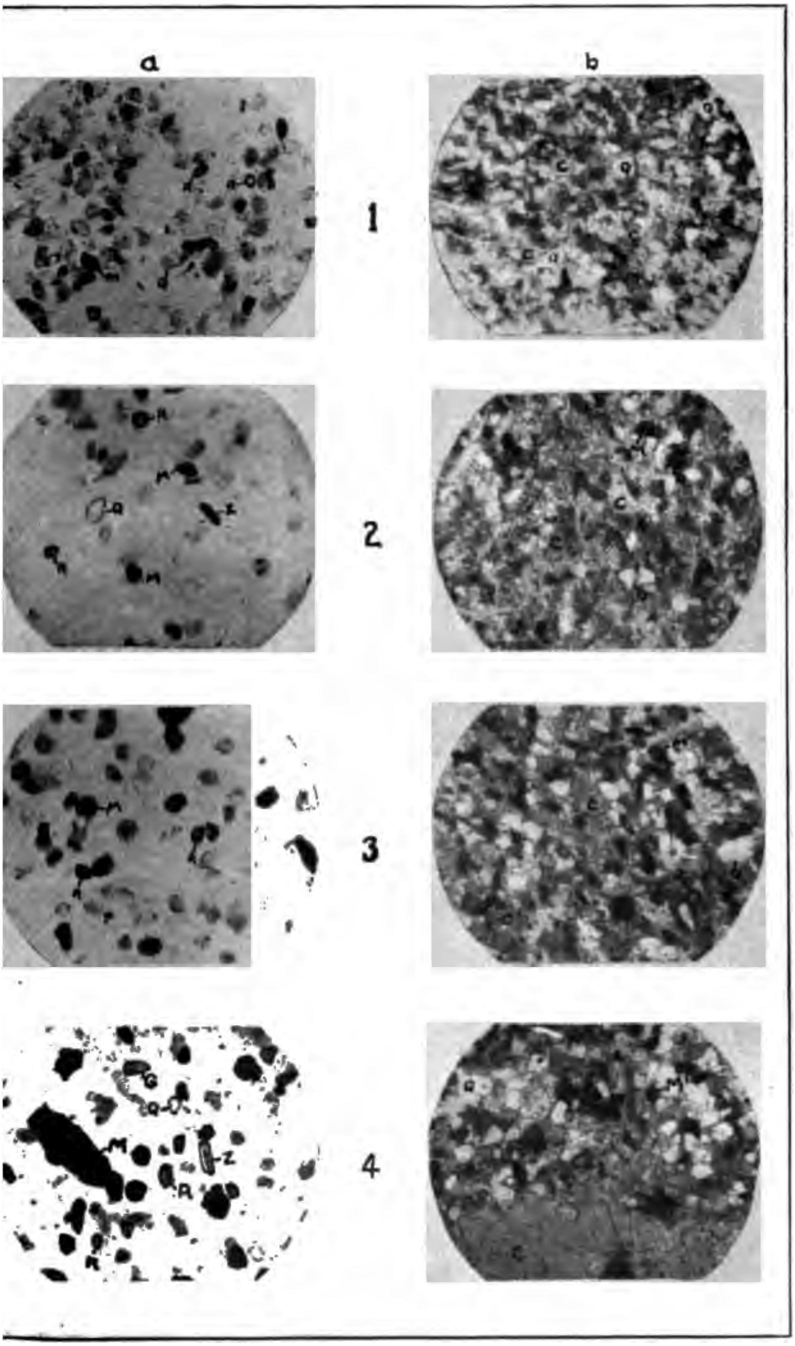
CLOSE VIEW SHOWING BEDDING AND JOINTING PLANES.

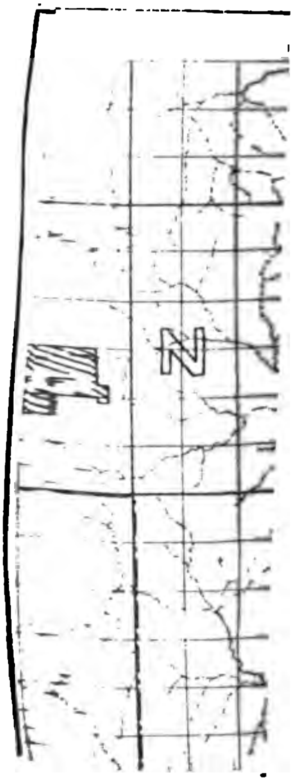
PHOTOMICROGRAPHS OF MINERAL GRAINS

Explanation of Plate IV

R—Rutile
M—Magnetite
Z—Zircon
Q—Quartz
C—Calcite
G—Garnet
a—Photomicrographs of heavy mineral grains
b—Photomicrographs of thin sections
1—Specimen No. 2
2—Specimen No. 3
3—Specimen No. 14
4—Specimen No. 15

PLATE IV.





March, 1922

OKLAHOMA GEOLOGICAL SURVEY

ernor J. B. A. Robertson, State Superintendent R. H. Wilson,
President Stratton D. Brooks, Commission.

C. W. Shannon, Director

CIRCULAR NO. 10

RESEARCH AND FIELD INVESTIGATION SERIES.
PAPER NO. I.

A SILURO-DEVONIAN OIL HORIZON IN SOUTHERN OKLAHOMA.

BY
GEO. D. MORGAN

1907

NORMAN

March, 1922

A SILURO-DEVONIAN OIL HORIZON IN SOUTHERN OKLAHOMA.

In August of the past year the Nance Syndicate well located sec. 4, T. 4N., R. 5E., Pontotoc County, Okla., encountered a nestone at a depth of 2,305 feet. The formation made a small ow of oil and after 105 feet of it had been penetrated, opera-ns were discontinued and the well was shot with 200 quarts nitro-glycerine. The shot was successful and the well came for an initial production of about 125 barrels per day. In acing the charge it was arranged so as to extend from the ttom of the well to within 15 feet of the top of the lime and ere is, therefore, no doubt that it was this formation that elded the oil.

At the time that the well was brought in the writer ob-ined a number of limestone fragments, which were thrown out the shot and from the fragments secured fossils which indi-ted that the formation was of Silurian age.

The surface deposits in the vicinity of the well are of late ennsylvanian age and in stratigraphic position belong at least 000 feet above the Seminole conglomerate of Taff. From a nsideration of the following Pennsylvanian stratigraphic lumn given by Taff for the Coalgate quadrangle, only 15 miles st of the well, it will be seen that an occurence of Silurian ks at the depth at which the limestone was encountered was rdly to be expected.

Pennsylvanian Formations of the Coalgate Quadrangle

By Joseph A. Taff.

Formation	Thickness in feet.
Seminole conglomerate	50
Holdenville shale	260
Wewoka formation	700
Wetumka shale	120
Calvin sandstone	145-240
Senora formation	140-485
Stuart shale	90-280
Thurman sandstone	80-260
Boggy shale	2,000-2,600
Savanna sandstone	1,000
McAlester shale	1,800-2,000
Hartshorne sandstone	150
Atoka formation	3,100
Wapanucka limestone	100

In order to obtain a more definite determination of the age the limestone, a small collection of fragments was sent to Dr.

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J. J. Galloway, Professor of Paleontology at Columbia University. From this collection Dr. Galloway was able to identify the following fossils:

Dalmanella clegantula (Dalman), typical specimens.

Spirifer crispus (Hisinger), probably the variety S. crispus simplex (Hall), since it lacks the zig-zag growth lines of S. Crispus.

Wilsonia saffordi (Hall), brachial valve.

Ceolospire hemispherica (Sowerby), doubtful.

Calymene niagarensis (Hall), two free checks.

Ostracods, probably *Bythocypris* sp. undescribed.

Bryozoan, young, like *Ceramopora*.

From the evidence afforded by these Dr. Galloway stated, that in his opinion, the formation was of Niagaran age, probably the equivalent of the Henryhouse shale of the lower Hunton formation which outcrops in the Arbuckle Mountains some 12 miles to the south of the well.

Shortly after the Nance Syndicate well was brought in, the Trans-continental Oil Company's well, in sec. 14, T. 5N., R. 4E., some 6 miles to the northwest encountered a similar lime at 2,660 feet. This lime differed from that in the Nance well in that it was only 50 feet thick and made but a very small showing of oil. No fossils were secured from it but the similarity of the logs of the two wells and their proximity strongly indicate that the two occurrences are parts of the same formation.

It is difficult to explain the disparity of the thickness at the two localities. Four possibilities here suggest themselves, but so far evidence is not at hand to justify a definite conclusion.

1. The formation may thin northward.
2. Toward the north the upper or lower parts of the formation may grade into shales, indistinguishable from the associated strata.
3. Emergence at the northern end of the area, during part of the time at which the Hunton of the Arbuckle Mountains was being deposited, may have prevented deposition of part of the formation to the north.
4. Folding and erosion prior to the deposition of the overlying Pennsylvanian strata may have resulted in the removal of the upper portion of the formation at certain localities.

Shortly after the discovery of the limestone in the Trans-continental well considerable excitement was caused by the bringing in of the Maud Oil and Gas Company's well, No. 2, located in sec. 18, T. 7N., R. 5E., about 12 miles north of the Trans-continental well. The producing horizon at Maud was also found to be a limestone and resembled the bed in the Trans-continental well, in that it was only about 50 feet thick, but differed from both the Nance and Trans-continental occurrences in that it was rather sandy.

Fragments of this lime were secured and, because of a suspicion that it was to be correlated with the limes farther south, some of these pieces were sent to Dr. Charles Schuchert of Yale University who was able to identify the following fossils:

Anoplotheca concava (Hall).
Phacops (probably *P. hudsonicus* or *P. logani*).
Ostracoda, crinoidal fragments, and young of *Meristella*.

From this assemblage Dr. Schuchert stated that the lime of the Maud well was certainly of Heldebergian (Lower Devonian) age and considered it to be the equivalent of the upper Hunton formation.

It will be recalled that Chester A. Reeds* made a special study of the Hunton formation of the Arbuckle Mountains and in 1911 contributed a most helpful and interesting paper on the subject. In this article it was shown that the formation contained several unconformities and ranged in age from Niagaran

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* Reeds, Chester A., American Journal of Science, 1911, p. 256.

Correlation Table of the Siluro-Devonian Rocks, Arbuckle Mountains, Oklahoma

Period	Series	Stage	Reed 1911	Taff, Ulrich and Girty 1903-1904	
Devonian	Helderbergian	Becraft	Bois d'Arc Limestone 0-90' average 60'	Upper Hunton	Oriskany
		New Scotland	Haragan Shale 0-166' average 100'	Middle Hunton	Helderbergian
			Break		
Silurian	Niagaran		Henryhouse Shale 0-223' average 90'		
			Break		
	Alexandrian	Ohio Clinton	Chimneyhill Limestone Pink crinoidal member 0-39' average 15' Glauconitic member 0-25' average 15' Oolitic member 0-12' average 5'	Lower Hunton	Niagaran Clinton

(Middle Silurian) to Heldegergian (Lower Devonian). The preceding table, reproduced from his paper, shows the unconformities found by Reeds and the manner in which he subdivided the formation.

It is not known what significance attaches to the fact that the fossils from the Maud well indicate that the lime there belongs to the upper Hunton (Heldegergian) while those from the Nance well indicate that the formation at that place belongs to the lower Hunton (Niagaran). It may be that the apparent absence of portions of the formation in each locality is to be explained as a mere coincidence in the writer's selection of the few fragments which were sent to Dr. Galloway and Dr. Schuchert; or it may be that certain portions of the bed were more easily shattered and thus contributed a majority of the fragments available after the wells had been shot.

Since the finding of the lime in the Maud well it has been encountered in another locality. The Doan Oil Company's well in sec. 20, T. 5N., R. 4E., two miles west of the Trans-continental, penetrated limestone at 2,500 feet which, although no fossils have been secured from it, is almost certainly to be correlated with the lime in the Trans-continental well. The lime in the Doan well made only a negligible show of oil and was not shot.

To summarize, it may be said that in an area extending northward from the Arbuckle Mountains, through the western part of Pontotoc County and the southern part of Pottawatomie County, portions at least, of the Hunton limestone have been encountered at comparatively shallow depths, in four scattered wells. The formation dips toward the north, but at so slight an angle as to insure its presence within drilling depth over a large area. In two of the wells where the formation has been found it carried oil in commercial quantities and since it is apparently a new oil horizon for the State it should warrant further investigation.

For the benefit of those persons especially interested in the area, logs of the four wells mentioned are herewith included:

	Name and Location of Well	Depth at Which Limestone Was Found
1.	Nance Syndicate, Sec. 4, T. 4N., R. 5E., Pontotoc County, Okla.	2305 feet
2.	Transcontinental Oil Co. Sec. 14, T. 5N., R. 4 E., Pontotoc County, Okla.	2660 feet
3.	Doan Oil Company Sec. 20, T. 5N., R. 4E., Pontotoc County, Okla.	2500 feet
4.	Maud Oil and Gas Co., No. 2 Sec. 18, T. 7N., R. 5E., Pottowatomie County, Okla	3730 feet

gard No. 1, sec. 4, T. 4N., R. 5E., Pontotoc County, Oklahoma
Nance Syndicate.

acter of rock.	Thickness *Feet*	Depth *Feet*	Character of rock.	Thickness *Feet*	Depth *Feet*
e to clay	4	4	Sandy shale	45	865
ock	26	30	Blue shale	15	880
d	72	102	Red rock	25	905
ock	20	122	Water sand	30	935
hale	8	130	Blue clay	35	970
ck	22	152	Red rock	30	1000
shale	18	170	Blue shale	20	1020
gravel	15	185	Water sand	20	1040
ck	10	195	Blue clay	20	1060
shale	25	220	Black shale	50	1110
shale	10	230	Lime (hard)	12	1122
shale	15	245	Blue clay	15	1137
and	7	252	Black shale	30	1167
shale	48	300	Sandy shale	8	1175
ck	20	320	Red rock	15	1190
	10	330	Black shale	35	1225
ck	20	350	Water sand	25	1250
ay	10	360	Sand lime	25	1275
ck	20	380	Black shale	35	1310
	10	390	Lime shell	10	1320
ck	25	415	Blue clay	15	1335
ome	7	422	Black shale	39	1374
ck	8	430	Blue clay	16	1390
shell	2	432	Water sand	20	1410
ck	12	444	Blue clay	25	1435
nd	30	474	Blue sandy shale	45	1480
ck	36	510	Black shale	70	1550
hell	6	516	Sandy shale	10	1560
ck	34	550	Oil sand	20	1580
me	5	555	Ore sand (good)		
ck	20	575	(Showing of oil)	20	1600
lay	25	600	Black shale	15	1615
ck	20	620	Sandy lime	25	1640
hell	5	625	Black shale	70	1710
ay	10	635	Hard Shell	2	1712
sand	25	660	Black shale	63	1775
ck	45	705	Sand (oil)	3	1778
sand	25	730	Black shale	142	1920
ck	30	760	Sand (oil)	10	1930
sand	15	775	Brown and black shale	375	2305
hale	15	790	White lime	107	2412
	5	795	Still in lime		
ale	25	820			

Well—150 feet from N. line and 150 feet from E. line, sec. 14, T. 5N., R. 4E., Pontotoc County, Oklahoma

Transcontinental Oil Co.

Character of rock.	Thickness Feet	Depth Feet
Clay	27	27
Lime, hard, white	3	30
Shale, red soft	20	50
Shale, blue	17	67
Sandy shale, red	18	85
Sandy shale, red	12	97
Mud, blue	13	110
Shale, red	47	157
Water sand, white not enough for drilling	13	170
Mud, blue	5	175
Shale, red	50	225
Shale, gray	11	236
Shale, red, caving	74	310
Shale, gray	65	375
Sand, little water	5	380
Sandy lime	10	390
Water sand, white, 6 bailers per hour	12	402
Shale, blue	5	407
Shale, red	25	432
Water sand	13	445
Sandy lime	16	461
Shale, blue	22	483
Sandy lime, white, hard	12	495
Shale, red	140	635
Water sand, white	25	660
Lime, white, hard	5	665
Sand	12	677
Shale, blue	43	720
Lime, white hard	12	732
Shale, blue, soft	23	755
Shale, red	2	757
Slate, black	8	765
Water sand, white	10	775
Shale, blue	13	788
Shale, red	6	794
Sand, white	6	800
Shale, blue	16	816
Shale, yellow	8	824
Sand	10	834
Red bed	20	854
Sand	12	866
Mud, blue	6	872
Lime	15	887
Shale, soft, brown	16	903
Lime, and granite (this reported granite was probably pieces of feldspar in the lime.)	17	920
Shale, brown	2	922
Lime and granite (granite-pieces of feldspar in the lime)	3	925
Shale, brown, soft	13	938
Lime	2	940
Shale, brown	4	944
Shale, blue	24	968
Water sand	8	976
Shale, brown, soft	5	981
Lime, white, hard	4	985
Shale, brown	5	990
Water sand, white	6	996
Shale, brown	17	1013
Water sand	12	1025
Shale, brown	25	1050
Water sand (hole full of water	15	1065
Lime, hard	1	1066
Water Sand	9	1075
Shale, red, soft	49	1124
Water sand, white	8	1132
Lime, hard	2	1134
Shale, brown	26	1160
Shale, blue	95	1255
Shale, brown	10	1265
Shale, blue	10	1275
Water sand, white	20	1295
Lime	15	1310
Shale, blue	22	1332
Shale, brown	2	1334
Lime, white	10	1344
Shale, blue	68	1412
Shale, brown	18	1430
Shale, blue	25	1455
Sand, dry	10	1465
Shale, blue, soft	15	1480
Lime	5	1485
Shale, blue, soft	20	1505
Shale, black	10	1515
Shale blue	85	1600
Shale, black	5	1605
Shale blue	21	1626
Sand, show oil	2	1628
Shale, pink	2	1630
Shale, blue	72	1702
Sand, white (gas)	20	1722
Shale, blue	98	1820
Red bed	5	1825
Shale, brown	15	1840
Shale, black	25	1865
Shale, blue	35	1900

Well—150 feet from N. line and 150 feet from E. line, sec. 14, T. 5N., R. 4E., Pontotoc County, Oklahoma

Transcontinental Oil Co.—(Continued).

Character of rock.	Thickness Feet	Depth Feet	Character of rock.	Thickness Feet	Depth Feet
Shale, black	50	1950	Shale, blue, soft	70	2340
Shale, white, sandy	11	1961	Shale, black	42	2382
Lime, hard	4	1965	Shale, gray	15	2397
Shale, blue, soft	27	1992	Shale, gray	73	2470
Lime	5	1997	Shale, blue, soft	20	2490
Shale, blue, soft	63	2060	Shale, and lime shells	10	2500
Lime, hard	10	2070	Shale, black	80	2580
Shale, blue, soft	15	2085	Shale, brown	95	2675
Lime	5	2090	Shale, and lime shells		
Shale, blue, soft	52	2142	Hunton Ls.	10	2685
Lime	16	2158	Lime, white, hard	95	2780
Shale, blue	92	2250	Slate, soft	90	2870
Lime, brown	2	2252	Still drilling		
Sand, little water	18	2270			

W. V. Cook, Well No. 1, NE. cor., NW¼, NE¼, sec. 20, T. 5, R. 4E.

Doan Oil Co.

Character of rock.	Thickness Feet	Depth Feet	Character of rock.	Thickness Feet	Depth Feet
Sand and red mud	35	35	Lime shells	5	1031
Coarse gravel-water	20	55	Grey shale	16	1047
Red rock	25	80	Blue shale	5	1052
Coarse gravel	10	90	Lime	3	1055
Sand rock	10	100			
Red rock	140	240	Sand (Water sand at 1060 feet)	10	1065
Lime shells	15	255	Red rock	10	1075
Red rock	70	325	Sand	11	1086
Brown shale	62	394	Lime	4	1090
Lime	5	399	Red rock	3	1093
Brown shale	11	410	Lime	5	1098
Sand rock	15	425	Red rock	59	1157
Brown shale	15	440	Sand	8	1165
Red rock	45	485	Blue Slate	25	1190
Red sand rock	15	500	Red rock	15	1205
Red rock	65	565	Lime shells and shale	7	1212
Sand (Water at 580')	40	605	Blue slate	13	1225
Red rock	75	680	Blue shale	10	1235
Sand (Water)	12	692	Blue slate	10	1245
Red rock	46	738	Sand	5	1250
Lime shells	12	750	Blue slate	10	1260
Red rock	40	790	Sand	5	1265
Red rock-shale	25	815	Blue slate	5	1270
Red rock	160	975	Sand	10	1280
Lime	15	990	Blue shale	15	1295
Red rock	13	1003	Sandy lime	15	1310
Lime and shale	6	1009	Red rock	10	1820
White shale	5	1014	Sand	10	1330
Sand shell	1	1015	Sandy lime	23	1353
Red rock	11	1026			

W. V. Cook, Well No. 1, NE. cor., NW¼, NE¼, sec. 20, T. 5, R. 4E.

Doan Oil Co.

Character of rock.	Thickness *Feet*	Depth *Feet*
Sand	27	1380
Lime	5	1385
Blue shale	5	1390
Lime and sand shells (small oil show)	23	1413
Red rock	12	1425
Sand	5	1430
Lime	23	1453
Red rock	11	1464
Blue slate	22	1486
Brown shale and lime shells	14	1500
Blue shale	12	1512
Red rock	3	1515
Sand	10	1525
Slate	15	1540
Blue slate	5	1545
Blue slate	10	1555
Blue shale	15	1570
Blue slate	5	1575
Blue shale	11	1586
Blue slate	6	1592
Blue shale	3	1595
Blue slate	10	1605
Blue shale	10	1615
Red rock	17	1632
Blue slate	3	1635
Sand	5	1640
Blue shale	8	1648
Sand	12	1660
Blue slate	23	1683
Red rock	7	1690
Blue shale	20	1710
Lime	15	1725
Blue shale	7	1732
Blue slate	6	1738
Blue shale and sand shells	12	1750
Sand	15	1765
Blue slate	10	1775
Blue shale	6	1781
Lime	10	1791
sand—water	24	1815
Blue shale	5	1820
Blue shale and lime shells	7	1827
Blue slate	16	1843
Lime shells	7	1850
Lime	5	1855
Sand	2	1857
Blue slate	8	1865
Blue slate and lime shells	3	1868
Black shale	22	1890
Light blue shale	25	1915
Blue shale	27	1942
Black shale	20	1962
Lime shell	3	1965
Blue shale	17	1982
Lime-shells	3	1985
Blue shale	18	2003
Black shale	2	2005
Black slate	4	2009
Blue shale	6	2015
Black shale	10	2025
Blue shale	10	2035
Black shale	10	2045
Blue shale	5	2050
Sandy lime	10	2060
Black shale	65	2125
Blue slate	10	2135
White slate	10	2145
Blue slate	5	2150
Lime	30	2180
White slate	10	2190
White slate	10	2200
Black slate	5	2205
Blue slate	5	2210
Black slate	10	2220
Blue slate	8	2228
Black slate	10	2238
Black shale	7	2245
Black slate	15	2260
Sand—dry	20	2280
White slate	15	2295
Blue slate	25	2320
Sand water	5	2325
Black slate and lime shells	10	2335
Sand—water	10	2345
Lime, hard	5	2350
Lime	5	2355
Black slate	5	2360
Black slate	100	2460
Blue slate	25	2485
Black slate	15	2500
Sandy lime	5	2505
Sand and lime	10	2515
Sand	10	2525
Sandy lime, hard	5	2530
Lime, hard	10	2540
Lime, sand, and shale		

W. V. Cook, Well No. 1, NE. cor., NW¼, NE¼, sec. 20, T. 5, R. 4E.
Doan Oil Co.—(Continued).

acter of rock.	Thick-ness *Feet*	Depth *Feet*	Character of rock.	Thick-ness *Feet*	Depth *Feet*
ken formation)	10	2550	White shale	10	2655
nd shale	10	2560	White slate	10	2665
-black	10	2570	White shale	10	2675
-soft	5	2575	White slate	10	2685
-white	5	2580	White shale	40	2725
	5	2585	Blue shale	5	2730
hard	5	2590	Black shale	5	2735
hard	15	2605	Blue shale	5	2740
lime	10	2615	Black shale	5	2745
ime	5	2620	Blue shale	5	2750
slate	5	2625	Black shale	15	2765
slate	20	2645	Top of lime, hard	5	2770

WELL NO. 2, W. ½, of NE. ¼, sec. 18, T. 7N., R. 5E.
Maud Oil & Gas Co.

racter of rock.	Thick-ness *Feet*	Depth *Feet*	Character of rock.	Thick-ness *Feet*	Depth *Feet*
ck	30	30	Streaked shale	17	560
sand	30	60	Lime shell	14	574
ck	10	70	Blue shale	6	580
shale	25	95	Hard white sand	14	594
sand	10	105	Red shale	7	601
ud	5	110	Sandy blue shale	31	632
blue shale	50	160	Water, broken sand	8	640
ater sand	5	165	Sandy lime	20	660
shale	25	190	Red shale	7	667
ud	10	200	Blue shale	23	690
blue shale	40	240	Water sand	2	692
nd brown shale	10	250	Blue shale	8	700
brown shale	15	256	Gray lime	35	735
with water	5	270	Oil show—white sand	5	740
	20	290	Blue sandy	12	752
ud	2	292	Brown sandy	13	756
	38	330	Sand, light	10	775
ed brown and			Blue shale	21	796
	10	340	Dark coarse sand	5	801
shale	10	350	Blue shale	5	806
and red shale	10	360	Sandy lime	14	820
uddy shale	10	370	Light shale	5	825
hale	10	380	Sand hard, parafine		
shale	17	397	and oil	38	863
white sand	2	399	Red shale	7	870
nd brown	4	403	Mixed shale	15	885
hale	17	420	Lime shell	65	950
nd brown shale	10	430	Red rock	3	953
red mud	20	450	Sandy lime	8	961
and red shale	10	460	Blue shale	7	968
nd brown shale	30	490	Sandy lime shell	38	1006
lue shale	20	510	Blue and brown shale	2	1008
sandy slate	15	525	Water and sand	27	1035
little water	10	535	Sandy lime	5	1040
hale	8	543	Red rock	50	1090

WELL NO. 2, W. ½, of NE. ¼, sec. 18, T. 7N., R. 5E.
Maud Oil & Gas Co.—(Continued).

Character of rock.	Thickness Feet	Depth Feet
Blue shale	5	1095
Blue shale	20	1115
Sand hole full water	10	1125
Sand blue shale	7	1132
Sand	15	1147
Blue shale	18	1165
Lime shell	16	1181
Brown shale	4	1185
Brown shelly shale	10	1195
Blue shelly shale	45	1240
Blue shelly shale	15	1255
Blue shelly shale	55	1310
Sandy lime	80	1390
Blue shale	15	1405
Red shale	25	1430
Blue shale	20	1450
Shelly blue shale	5	1455
Blue shale	20	1475
Sand—little water	45	1520
Sandy shale	16	1536
Blue shale	34	1570
Blue lime	40	1610
Blue lime	10	1620
Black sand	5	1625
Brown mud	20	1645
Hard sand	25	1670
Blue shale	30	1700
Sandy lime	5	1705
Blue shale	85	1790
Pink shale	10	1800
Salt water—sand—some gas	10	1810
Hard sandy lime	10	1820
Sand	10	1830
Slate	8	1838
Blue slate	4	1842
Lime shell	6	1848
Blue slate	7	1855
Black slate	5	1860
White slate	11	1871
Blue slate	11	1882
Blue shale	8	1890
Gray lime	5	1895
Blue shale	30	1925
Slate caves	20	1945
Brown shale	25	1970
Hard lime	15	1985
Water sand—some water	15	2000
Blue shale	65	2065
Slate	75	2140
Gravel	5	2145
Red rock	5	2150
White lime	10	2160
Blue gravel	10	2170
Light gray shale	20	2190
Black slate	130	2320
Hard sand (Small lime shale on top of slate—no water)	5	2325
Slate	75	2400
Lime shell	5	2405
Sand	10	2415
Slate	30	2445
Lime	5	2450
Sand, dry, no water	10	2460
Black sand	25	2485
Gray shale	15	2500
Blue shale	60	2560
Sand salt water	25	2585
Broken slate	29	2614
Gray shale	31	2645
Slate	30	2675
Sand	10	2685
Sand	5	2690
Lime	18	2708
Lime and shale	12	2720
Hard lime shell	5	2725
Sticky shale	11	2736
Sticky shale	5	2741
Sticky shale	12	2753
Dark shale and shells	17	2770
Hard shell	6	2776
Blue shale	4	2780
Dark shale	10	2790
Lime shell shale	6	2796
Dark shale	54	2850
Blue shale	25	2875
Sticky shale	35	2910
Lime	10	2920
Blue shale	25	2945
Lime	16	2961
Gas showing sandy lime	4	2965
Blue shale	30	2995
Hard lime shell	5	3000
Blue shale	70	3070
Hard shale	5	3075
Blue shale	45	3120
Oil and gas showing, sand	4	3124
Blue shale	43	3167
Sand, (show oil and		

WELL NO. 2, W. ½, of NE. ¼, sec. 18, T. 7N., R. 5E.
Maud Oil & Gas Co.—(Continued).

Character of rock.	Thickness Feet	Depth Feet	Character of rock.	Thickness Feet	Depth Feet
gas) water in bottom	85	3252	Blue slate	8	3468
Blue shale	90	3342	Show gas, lime shell	6	3474
Show gas, lime shell	6	3348	Brown slate	26	3500
Blue shale	17	3365	Dark blue slate	20	3520
Gas show—shell	4	3369	Brown slate	80	3600
Blue shale	47	3416	Blue shale	15	3615
Lime shell	3	3419	Brown slate	115	3730
Blue slate	31	3450	Oil sand	45	3775
Some water (3 bailers per hour)			Blue green shale	19	3794
			Hard shelly formation	12	3806
Sandy shale	10	3460	Blue shale	16	3822

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CIRCULAR NO. 11

RESEARCH AND FIELD INVESTIGATION SERIES.
PAPER NO. II

:KOSE OF THE NORTHERN ARBUCKLE AREA.

BY
GEO. D. MORGAN

OCT 1

1907

NORMAN

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GEO. D. MORGAN

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ARKOSE OF THE NORTHERN ARBUCKLE MOUNTAIN AREA.

Extending along the northern flank of the Arbuckle Mountains is an arkosic series which bears an important time relation to the orogenic movements of that region.

These deposits have been chiefly studied, and are typically developed, in the western part of Pontotoc County, and it is therefore suggested that they be known as the Pontotoc series, but by no means is it to be inferred that their outcrop is limited to the confines of the county indicated. The lower contact of the formation has been traced along an irregular line from the vicinity of Sulphur northeastward through Dolberg, to the west of Ada, across Canadian River to the west of Tyrola, to the east of Konawa and to the northern limit of the Stonewall quadrangle through the eastern side of sec. 16, T. 6N., R. 6E. Beyond this point the contact has not been carefully followed, but the formation is known to continue in the same general direction for a number of miles. From Sulphur the contact turns westward along a line about parallel with the Arbuckle Mountains and has been traced in that direction as far as the Atchison, Topeka, and Santa Fe Railway.

As noted later, the upper contact of the series is more difficult of definition than the lower, but the fact that the two are separated by a large areal extent of the formation is evidenced by the presence of arkosic strata at the following rather widely scattered localities: Wynnewood, Hart, Vanoss, Bebee, a point one mile south of Stratford, Maxwell, and just east of Konawa.

The strata comprising the series consist of coarse sandstones, shales, and impure, argillaceous or arenaceous limestones. The sandstones are made up almost entirely of quartz and feldspar, although some fragments of limestone are always present,

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The writer wishes to acknowledge his special indebtedness to Mr. A. E. Brainerd, until recently Professor of Geology at Syracuse University; to Dr. L. C. Snider, Chief Geologist for the Empire Gas and Fuel Company; Dr. David White, Chief Geologist for the United States Geological Survey; and to Dr. J. W. Beede of the Texas Bureau of Economic Geology. Mr. Brainerd has assisted in all the field work upon which this article is based; Dr. Snider has made two reconnaissance trips through the area with the writer; Mr. Shannon has assisted with valuable information and suggestions, and Dr. White and Dr. Beede are authority for the identification of fossils.

The writer is now engaged in making a geological survey of the Stonewall quadrangle, the results of which will be published in a bulletin of the Oklahoma Geological Survey. The present preliminary article is published by the permission of the Empire Gas and Fuel Company.

and locally, limestone pebbles predominate to such an extent that almost pure limestone conglomerates are the result. The shales and limestones of the series always carry quartz and feldspar, although in varying degree. The feldspar is sometimes so abundant as to form a large percentage of the total.

The source of most of the material comprising the beds was the Arbuckle Mountains. Proximity of the series to the mountain mass and the close similarity between the feldspars in the arkose and those in the igneous rocks of the mountains constitute sufficient evidence to justify this conclusion. In addition, the presence in the series of fragments and pebbles of limestone which by their contained fossils may be identified as belonging to limestones outcropping in the Arbuckles would apparently leave no room for doubt.

The grains of quartz and feldspar are quite distinct and well separated and are of large size. Even in outcrops remote from the mountains it is not unusual to find great numbers of almost perfectly preserved orthoclase crystals averaging more than a quarter of an inch in length. Such evidence is taken to indicate that periods of torrential distribution of these materials alternated with long quiescent periods during which the contributing igneous mass weathered and crumbled in situ. Whether the coarse fragments and crystals, and their distribution are entirely the result of variation in rainfall which caused periodic removal of weathered igneous material, or whether they indicate recurring uplifts are questions difficult of proof, but the general evidence leads to the conclusion that both these processes contributed.

The thickness of the Pontotoc series is not accurately known, but is thought to be between 1,000 and 1,500 feet. In a general way the formation may be divided into three parts. The lowest of these comprises alternating strata of sandstones, conglomerates, and shales, each carrying a large percentage of feldspar, which for the most part is pink orthoclase, but which locally consists of more basic varieties. The middle portion also carries sandstones, but the shales are thicker and more numerous, and in addition a total thickness of about 100 feet of impure limestones is present. The quantity of feldspar in this portion is about the same as it is in the lower part. In the upper division shales predominate. Limestones are almost entirely absent and although there are a few local occurrences of grits and conglomerates, the sandstones become thinner and more fine-grained with a consequent decrease in the size of the feldspar particles.

The base of the series as defined in this paper is easily distinguishable. For an example of the sharpness of this lower contact the reader is referred to the bluff on the west side of Sandy Creek about 300 feet west of the southeast corner of sec. 9, T. 3N., R. 5E. To reach this bluff from Ada, the nearest railroad point, one travels southwestward over the upturned edges of northwestward-dipping sandstones, shales, and conglomerates, none of which contain megascopic feldspar,* but on crossing Sandy Creek and climbing the bluff in question a sandstone is suddenly encountered which contains such a quantity of pink orthoclase as to give it almost the appearance of a true granite. From this point westward for a number of miles it is difficult to find even a small piece of rock which does not contain an appreciable amount of feldspar.

Although clearly marked by feldspar the base of the formation is not defined by any traceable or distinctive stratum. The sandstones throughout the entire series are given to rapid and complete gradation into shales or impure limestones, and these in turn intergrade so often and so completely that an individual bed is rarely to be found which can be followed for more than a few miles. In addition to this variability caused by intergradation, mapping of individual beds over large areas is made practically impossible by the presence of numerous, small unconformities within the series.

Since these difficulties have precluded the possibility of mapping any one stratum as the base of the formation the writer has resorted to the use of feldspar fragments in the same manner that distinctive or index fossils are used in the identification of strata. That is the base of the Pontotoc series has been considered as being represented by a line drawn through those points at which, (on going upward through that portion of the stratigraphic column of the Stonewall quadrangle which lies above the Holdenville shale) megascopic feldspar is first encountered. The top of the formation is less definitely marked than the base and up to the present has received less study than has been given to the lower contact, but it has been observed that as one ascends through the series the quantity of feldspar in the rocks gradually diminishes and finally disappears. The general line along which this total disappearance takes place has been considered as the top of the series.

In defining the base of this formation as being represented by the first arkosic series occuring above the Holdenville shale it is probable that an entirely unnecessary precaution is taken. A thin conglomeratic sandstone, however, carrying some igneous pebbles has been found in the southwestern part of the Allen oil field. This stratum occurs near the base of the Wewoka formation which underlies the Holdenville shale and it is desired to prevent any possible confusion. Between the Pontotoc series and the sandstone just mentioned there are more than 1,000 feet of strata, and in none of these has there been found a single piece of arkosic material.

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* The writer has not made a microscopic examination of these rocks below the Pontotoc series, but no feldspar has been revealed by the use of an ordinary hand lens.

In view of the conclusions which are drawn in this paper it is desired to make a tabular comparison of the igneous material found in these two formations.

PONTOTOC SERIES	CONGLOMERATIC SANDSTONE OCCURRING IN THE WEWOKA FORMATION SOUTH OF ALLEN
1. Components entirely separated.	1. Components interlocked. (Complex pebbles)
2. Fragments and crystals angular.	2. Fragments rounded and well water-worn.
3. Grain coarse.	3. Grain (of pebbles) fine to microscopic.

From the foregoing it will be seen that the materials are entirely dissimilar and it is therefore concluded that the sources of the two types were dissimilar.

The restricted range and small areal extent of the pebbles found in the Allen exposure indicate one, or a combination of the following possibilities:

1. The condition of deposition was quite temporary; or
2. The source of the material was small and quickly exhausted.

The well rounded character of the pebbles might be taken to indicate that through the operation of some temporary current they had been brought in from a remote locality. On the other hand, the texture is that of near-surface igneous types and it may be that the particles were derived from dike or sill rocks which were exposed in the adjacent Arbuckles at, or near the time of the deposition of the basal beds of the Wewoka formation.

In the foregoing discussion an attempt has been made to show that during the time intervening between the deposition of the pebble bearing sandstone of the Allen area and the initial beds of the Pontotoc series no large igneous mass was exposed in the territory adjacent to the area under consideration.

AGE OF THE PONTOTOC SERIES.

It was only after a long search that a sufficient number and variety of fossils were found to establish the age of the formation.

Early in the course of the work a few poorly preserved gastropods were collected from an impure limestone and sent to Dr. J. W. Beede for identification, but he reported that they all belonged to the genus *Bulimorpha* and were insufficiently distinctive to establish the age of the beds as anything closer than Carboniferous.

ater a shale was found, just north of the town of Center, which a plant collection was taken and sent to Dr. David for identification. Dr. White reported the following : *'Neuropteris ovata,* the large form of upper Pennsylian age; *Pecopteris arborescens* and *Pecopteris hemi telio-* ragments of *Cordaites,* and probably *C. communis;* indeable fragments of *Calamites* indeterminable stem frag- possibly belonging to a fern; a few small fragments of a species of *Pecopteris* comparable to *P. ("Callipteridium") ianum,* or one of the closely related species from the augh and Dunkard of the Appalachian trough; and a fern ication, probably a new species, if not a new genus', and that in his opinion the shale was late Pennsylvanian .

ill later a very fossiliferous limestone was found along the bluff of Canadian River, about three miles north of the of Bebee, and from this a marine fauna was taken which to corroborate the opinion of Dr. White. All of these bearing beds were found in the middle or upper part of ries.

aving thus determined the presence of an arkosic series western part of the Stonewall quadrangle and having that the underlying formations, although often conglom- contain no observable feldspar, it would appear that a f stratigraphic "bench mark" has been established to reference may be made with some degree of assurance hich should be of great service in the solution of the ms of the Arbuckle Mountain region.

fter six months work in the Stonewall quadrangle, it is the e opinion of the writer that the base of the Pontotoc series time equivalent of the period at which the Arbuckle ains were worn down to their igneous core.

7.+

J A Taff

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CIRCULAR NO. 12

RESEARCH AND FIELD INVESTIGATION SERIES.

PAPER NO. III

STRATIGRAPHIC POSITION OF THE FRANKS AND SEMINOLE FORMATIONS OF OKLAHOMA.

BY

GEO. D. MORGAN

1907

NORMAN

March, 1923

STRATIGRAPHIC POSITION OF THE FRANKS AND SEMINOLE FORMATIONS OF OKLAHOMA.

INTRODUCTION.

The Franks and Seminole conglomerates of southern Okla- na have been subjects of discussion and dispute since the days Taff's early work in the state. During the last two years* · writer has spent considerable time in an investigation of se and associated formations, and it is thought that data are v at hand which will largely clear up the problems which they sent. Mr. A. E. Brainerd has ably assisted in most of the rk and the aid and suggestions which he has given cannot be highly valued. Credit is also due Mr. D. G. Barnett and Mr. lliam J. Stahl, who assisted in the capacity of instrument men.

REVIEW OF LITERATURE.

In any discussion of the Franks and Seminole conglomerates s essential that a review of the literature be given, otherwise re would be but slight excuse for treating the two formations ether.

In 1902 Taff apparently implied a correlation of the Franks glomerate with the Wapanucka limestone. In discussing the panucka limestone on page 4 of the Atoka folio he says: ıe formation comes from beneath the flat Cretaceous deposits mile northwest of Boggy Depot and continues northwest- rd in its tortuous outcrops to about six miles beyond the north- st corner of the quadrangle where it becomes so thin that it not be traced farther. At this western extremity it joins s of limestone conglomerate which thicken westward to enor- us proportions around and across the northwestern part of Arbuckle Mountain uplift."

In 1903 the same correlation is apparently implied on page the Tishomingo folio. Speaking of the Franks conglomerate f says: "A broad belt of this conglomerate extends across northwestern part of the Arbuckle Mountains to the vicinity Franks, in the adjoining Stonewall quadrangle. From the thwest corner of the Tishomingo quadrangle northeastward it sses the eroded edges of the Ordovician, upper Silurian and onian formations. From a nearly flat position on the Hunton estone near Franks it extends southeastward unconformably oss the Woodford chert and Caney shale to a position above the latter in the upper Carboniferous section. Between Franks and the southeast corner of the Stonewall quadrangle the formation changes from a heavy limestone conglomerate interbedded with sandstone and shale, to a thinner formation of fragmental limestone, shale and sandstone. At the latter point it is found to occupy a position in the section approximately the same as that of the Wapanucka limestone, at the top of the Caney shale."

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*This article is published by permission of the Empire Gas and Fuel ıpany, which organization has made possible this strictly scientific in- igation. The Oklahoma Geological Survey has co-operated in the work a complete report on the entire Stonewall quadrangle of Oklahoma is in preparation and will be published as a bulletin of the Survey. The l report will be submitted to Columbia University in partial fulfillment he requirements for the degree of doctor of philosophy.

In 1904, when Taff wrote Professional Paper No. 31, his opinion that the Franks conglomerate was the approximate equivalent of the Wapanucka limestone seems unchanged.

These are the only references to the Franks conglomerate, by Taff, which have been found, but while his work is being considered it is desired to point out that in no way did he consider that formation related to the Seminole conglomerate. In the Coalgate folio he places the Seminole conglomerate at the top of his Pennsylvanian section, and when it is borne in mind that he consistently assigned the Franks to a position at the base of the Pennsylvanian it becomes obvious that he had no impression other than that the two formations were widely separated.

The name Seminole conglomerate was applied to a small area of sediments which outcrop in the northwestern part of the Coalgate quadrangle. In his definition of this formation Taff says:* "About 50 feet of the lower part of the Seminole conglomerate is exposed in a small area in the northwestern corner of the Coalgate quadrangle. This part of the formation is composed of laminated or stratified subangular chert with a sprinkling of quartz pebbles from 3 inches in diameter to small grains in a cement of fine and usually ferruginous sand. The coarser conglomerate in the beds at the base is loosely cemented and on weathered surfaces it breaks down into rounded boulders and loose gravel. Forty to 50 feet from the base the conglomerate grades into brown sandstone which continues upward about 100 feet to the top of the formation. The Seminole formation crops in a rugged hilly country northwestward in Seminole Nation, making rough timbered lands."

The item of paramount importance in this definition is that Taff limits the thickness of the Seminole conglomerate to about 150 feet.

In 1910 Reeds** followed Taff and assigned the Franks a position of "apparent conformity above the Caney Shale".

In 1915 Wallis*** followed Taff and correlated the Franks glomerate with the Wapanucka limestone.

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*Taff, J. A., U. S. Geol. Survey Geol. Atlas, Coalgate folio (No. 74) P. 4, 1901.

**Reeds, Chester A., A report of the geological and mineral resources of the Arbuckle Mountains, Oklahoma: Okla. Geol. Survey Bull. 3, 1910.

***Wallis, B. Franklin, The geology and economic value of the Wapanucka limestone of Oklahoma: Okla. Geol. Survey Bull. 23, 1915.

In 1921 Moore* quoted a personal communication from oy** to the effect that the Franks conglomerate had been ed from the vicinity of Sulphur northeastward across central totoc County, near Ada, into Seminole County and was there d to be identical with the Seminole conglomerate. This was ide divergence from the interpretation of Taff and at one ke lifted the Franks conglomerate from the base to a position r the top of the Pennsylvanian section. McCoy's correlation taken by Moore to indicate a totally different history for the uckle Mountains than that previously suggested and his conion was that: "It seems apparent that the Arbuckles were fted after the time of deposition of the Pennsylvanian beds heast of the mountains, that they were reduced to a penen and that gravels were strewn across the eroded edges of beds". He believed that these gravels were represented by Franks and Seminole conglomerates.

In the latter part of 1921 McCoy published a paper*** in ch he stated that "the Franks conglomerate of the western uckle region must be correlated with the Seminole conglomerof east central Oklahoma. The conglomerate at Franks, Oklaa, where the same received its name, cannot be traced detely into any stratigraphic zone, but according to the posiof the Wapanucka formation it has probably been erronly correlated with that particular horizon."

In correlating the Franks conglomerate of the western Arkle area with the Seminole conglomerate McCoy gives a ifying footnote in which he states that: "The conglomerate ed 'Seminole' in this paper is the main horizon in a series of glomerates, the lower part of which was named the Seminole glomerate by Taff in the Coalgate folio."

A summary of the various interpretations which have been lished regarding the two formations follows:

Taff considered all the limestone conglomerates of the immediate Arbuckle area as one formation to which he gave the name Franks.

Taff, followed by Reeds and Wallis, considered the Franks to be situated at the base of the Pennsylvanian section and essentially equivalent to the Wapanucka limestone.

Taff placed the Seminole at the top of his Pennsylvanian section in the Coalgate folio, i. e., above the Holdenville shale, and defined it as having a thickness of about 150 feet.

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*Moore, Raymond C., Folding in southern Oklahoma oil fields: Am. c. Pet. Geol., Vol. 5, No. 1, p. 40, 1921.

**McCoy, Alex W.

***McCoy, Alex W., A short sketch of the paleogeography and historical ogy of the Mid-Continental district and its importance to petroleum geo-: Bull. Am. Assoc. Pet. Geol., Vol. 5, No. 5, 1921.

4. Moore took, quite literally, McCoy's statement that the Franks and Seminole were equivalent and drew conclusions on that basis.
5. McCoy correlated the Franks conglomerate of the western Arbuckle area with the Seminole conglomerate, but qualified this correlation by changing Taff's definition of the Seminole to embrace a much greater thickness of deposits.

PONTOTOC SERIES.

As previously stated the writer has had the good fortune to spend considerable time in an investigation of the formations under discussion. The particular region to which this investigation has been largely confined is the Stonewall quadrangle. This embraces parts of Pontotoc, Pottawatomie, Seminole, Coal, Johnson, Murray, and Garvin counties, and is a critical area in the present connection, because it includes the type section of the Franks conglomerate and adjoins the type section of the Seminole.

Early in the work it was observed that the strata in the western part of the Stonewall sheet were uniformly conglomeratic, and not only conglomeratic, but arkosic as well, and in some places the quantity of feldspar carried by individual beds constitutes as much as 50 per cent of the rock. In a preliminary paper* attention was called to this arkosic series** and the name Pontotoc was suggested for it. At the time of publication the boundaries of the series had not yet been carefully surveyed. The main conclusions of the paper were that the arkose occurs at the top of the Pennsylvanian section*** north of the Arbuckle Mountains, that it is of very late Pennsylvanian age, and that its initial appearance in the section marks the time at which the Arbuckle Mountains were worn down to their igneous core.

If these conclusions are essentially correct, then there must have been far earlier Pennsylvanian uplifts of the Arbuckle area, followed by long periods of erosion, in order that some 10,000 feet of early Paleozoic limestone might have been removed from the crest of the mountains before the time of deposition of the

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*Morgan, Geo. D., The arkose of the northern Arbuckle area: Okla. Geol. Survey, Cir. 11, 1922.

**The term series rather than formation is used because the beds have been found to have, in common, the one characteristic of being arkosic. Several rather distinct units have been noted within the series, however, and it is thought that in the course of subsequent work these may be found sufficiently distinct to be mapped as separate formations.

***See exception noted on p. 5 of paper mentioned kosic Pontotoc series. To follow this thought for a moment, it pears that if earlier uplifts occurred, thus exposing the lime- ne strata of the Arbuckles, then conglomerates, bearing frag- nts of this material, should be found in the earlier Pennsyl- nian formations, **and this is the case.** Conglomerates bearing sily identifiable fragments of Hunton and Viola limestones ve been found in abundance in the Wewoka formation, the urman sandstone, the Boggy formation, the Savanna and the Alester, consequently, the idea that the Arbuckle Mountains re not uplifted during the Pennsylvanian until Seminole time y be abandoned.

ELATION OF CONGLOMERATES AT SULPHUR TO THE PONTOTOC SERIES.

After determining that the arkosic strata constituted a de- ite and mappable series, the writer followed them north and uth and in the course of this work found them to include all e conglomerates in the vicinity of Sulphur which Taff had re- rred to as Franks.

RELATION OF CONGLOMERATES AT FRANKS AND SULPHUR.

As has been stated, the presence of feldspar grains in the ntotoc strata is a most important criterion for the recognition the series, and in view of Taff's correlation of the feldspathic nglomerates at Sulphur with the conglomeratic strata in the inity of Franks, it appears that the latter should also carry dspar. This is not the case, however. A search extending er a period of several months failed to disclose a single grain feldspar in the Franks conglomerate of the type area, and on e basis of the negative evidence thus afforded, the conclusion here drawn that the strata in the two localities (Franks and lphur) are of different age and are not to be correlated. Con- butory evidence, supporting this conclusion, is afforded by a mparison of the structural and faunal relations of the strata the two areas. It was observed that the conglomerates at anks do not have a "nearly flat position" as stated by Taff,* t in reality are highly folded and faulted.** At numerous ces dips as high as 80 degrees were measured, and at a few ints about a mile southwest of Franks the conglomerates were nd to be overturned. This structural condition of the Franks compared with that of the Pontotoc series shows that the ter has a uniformly low dip even where it extends far out over e flanks of the mountains. The area south of Sulphur is an stration. Lastly, it was found that in addition to the com- sitional and structural differences of the conglomerates in the two areas, some of the strata at Franks are quite fossiliferous, whereas fossils in the Pontotoc series are extremely scarce.

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*Taff, J. A., U. S. Geol. Survey Geol. Atlas, Tishomingo Folio (No.). 1903.

**In a later paper it will be shown that the faulting contributes impor- t evidence with regard to the geological history of the Arbuckle area.

It is thought that these three differences constitute ample evidence to justify the conclusion that the conglomerates at Franks and Sulphur are totally different in age and are not to be correlated. The criteria are important in another connection and are therefore listed in tabular form:

FRANKS CONGLOMERATE	PONTOTOC SERIES (which includes conglomerates at Sulphur)
1. Non arkosic.	1. Arkosic.
2. Highly folded and faulted.	2. Slightly folded.
3. Fossils common with numerous species.	3. Fossils scarce, with few species.

RELATION OF THE PONTOTOC SERIES TO THE SEMINOLE CONGLOMERATE.

Satisfied with the conclusion that the conglomerates at Sulphur and Franks were distinct as to age and not to be correlated, the writer then followed the Pontotoc series northward and found its lower contact, which could be traced quite easily in this direction, passed about 8 miles to the west of the Seminole outcrop as defined by Taff. Since the normal dip in the region west of the type area of the Seminole averages about one degree slightly north of west, the only possible conclusion was that the two formations were separated by a great thickness of intervening strata.

Because of overlaps within these intervening beds it is impossible to give a geological section of the strata between the Pontotoc and Seminole formations which will be representative for any great distance north and south. A section taken along the north line of township 5 north, however, may be considered as an average and is given in the section included herewith.

SEMINOLE CONGLOMERATE.

A correlation of the conglomerates at Sulphur with the Seminole conglomerate is obviously a dangerous step. This is so, not only for the reason that the two formations are widely separated by strata, some of which are of an altogether different nature, but for the additional reason that if any attempt is made to extend the Seminole to embrace all the conglomeratic strata of the area, the Holdenville and Wewoka formations, as well as several lower ones, might well be included. Chert conglomerates of the Seminole type are quite common throughout almost the entire Pennsylvanian section of the area north and northeastward of the Arbuckle Mountains. Those which occur below the Pontotoc formation have so close a lithologic similarity as to be indistinguishable, but the conglomerates of this type within the Pontotoc series are easily recognizable because of their contained feldspar.

ıe Seminole formation (not the conglomerate, for this is developed only locally) is sufficiently distinct for the ɘs of mapping. Its relation to certain key beds is now established. About 100 feet above the top of the 50-foot neratic phase of the type area, and resting upon what is ıken as the top of the formation, there is a thin, easily ıle limestone (DeNay limestone member) which was fol- 'rom the type area southwestward to a point southwest of here it is overlapped by succeeding formations. As a on the correlation here involved, two limestones in the ʼing Holdenville formation (the Sasakwa and Homer lime- nembers) have been traced from the northwest corner of ınewall quadrangle to their point of overlap southwest of nd as an additional check the very characteristic shale ıove the DeNay limestone member, in the basal part of the ng Francis formation, has been mapped.

.e mapping of these several key beds has somewhat dissi- ınother long accepted belief regarding the Seminole. In ginal description Taff states that the Seminole rests un- nably on the Holdenville and at one point in the north- . part of sec. 18, T. 6 N., R. 8 E., in the type area the has observed such an unconformity. It has not, however, ɔted in any other locality, and it is thought that since the tion of Taff's statement the relationship has been largely ıphasized. This is indicated by the fact that there is but variation in the interval between the upper limestone : (Sasakwa) of the Holdenville formation and the basal De- ıestone member of the overlying Francis formation. With eption of the Pontotoc series there is a general southward g of all the formations in the Stonewall quadrangle but interval just mentioned this thinning is not in excess of .eral average.

first investigation Taff's definition of the Seminole ap- uite clear, but there are several factors which contribute ıse the geologist who attempts to apply this definition in .d. Foremost among these is the fact that if only 150 hich Taff gives as the approximate thickness of the Sem- ɜ measured upward from the base of the formation as de- y Taff, it is found that "in a northwestward direction" ıinole formation barely extends into the old Seminole Na- 'he chance for confusion here lies in that part of Taff's on in which he says: "The Seminole formation crops on ged hilly country northwestward in Seminole Nation mak- gh timbered lands".

ıer possibilities for confusion are that (1) there is now ıole County, the boundaries of which do not coincide with f Seminole Nation; and (2) that there is also a town by ıne which, although lying within the limits of the present

County and the old Nation, is to the west of the outcrop of the Seminole formation. The latter condition is especially confusing because chert conglomerates almost identical in appearance with those of the Seminole formation, (but in reality much higher in the section) are reported to outcrop in the vicinity of the town.

In an endeavor to eliminate these possibilities of confusion, but at the same time to follow as nearly as possible Taff's definition of the formation. the limits of the Seminole formation are here taken to be as follows:

At the base of the formation there are 30 to 50 feet of chert conglomerates or coarse brown sandstones, depending upon the local variations of this member. The basal part of this member which is taken as the bottom of the Seminole formation may be further defined as occurring about 35 feet above the Sasakwa limestone member of the underlying Holdenville formation. The Sasakwa limestone varies in thickness from 1 to 15 feet; its outcrop passes through the town of Sasakwa, and it is especially well exposed in the railroad cut and quarry about one-fourth mile south of the town.

Upward through the Seminole formation the conglomerates and sandstones become thinner and the percentage of shale increases. At the top of the formation (which in accordance with Taff's definition is taken to be about 150 feet above the base) there is a thickness of from 15 to 30 feet of almost unbroken greenish-blue shale which is capped by the DeNay limestone[*] member of the overlying Francis formation. This limestone bed takes its name from DeNay school house which is located in sec. 5, T. 4 N., R. 7 E., about one-fourth mile east of the outcrop of the bed. This limestone has been traced from the northeast corner of the Stonewall quadrangle to Ada and beyond, and was found to be especially well exposed at the following points:

In the northeastern part of sec. 13, T. 6 N., R. 7 E.
In the northeastern part of sec. 26, T. 6 N., R. 7 E.
Along the west line of the SW¼ of sec. 35, T. 6 N., R. 7 E.
About 700 feet S. of the NE cor. sec. 9, T. 5 N., R. 7 E.
At the NE cor. sec. 7, T. 4 N., R. 7 E.
Where Little Creek crosses the road about 900 feet east of SW cor. sec. 13, T. 4 N., R. 6 E.

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[*] The DeNay limestone is taken as the upper limit of the Seminole formation, first, because it is a definite mappable bed which can be followed for many miles, and second, because it occurs about 150 feet above the base of the Seminole formation which thickness is in agreement with that assigned to the formation by Taff.

The DeNay limestone has been included as the basal bed of the Francis formation rather than the upper bed of the Seminole formation for the reason that in his definition of the Seminole, Taff does not mention any limestone member.

It is also well exposed at many points intervening between these mentioned as well as at many places further toward the southwest.

It is thought that if geologists adhere to the limits here used the confusion which has existed regarding the stratigraphic position of the Seminole formation will be eliminated.

FRANKS CONGLOMERATE.

Since the conglomerates at Sulphur are to be correlated with the Pontotoc series, and therefore occupy a position in the geologic section far above the Seminole conglomerate, and since they have been shown to be different in composition, structural conditions, and fossil content from the conglomerate at Franks, the question naturally arises as to the possible relation of the true Franks and Seminole conglomerates in their widely separated type areas. Before undertaking a consideration of this problem, however, it is desirable to inquire more fully into the true nature, condition, and associates of the Franks conglomerate.

The town of Franks is situated in the northern part of sec. 35, T. 2 N., R. 6 E., near the southern edge of a triangular area of Pennsylvanian sediments. The sides of the triangle converge westward and intersect in the eastern part of sec. 23, T. 2 N., R. 5 E. Beyond that point no Pennsylvanian strata are encountered until the outcrop of the Ada formation is reached in the vicinity of Roff.

In its western portion both sides of the triangle are defined by faults which bring the Pennsylvanian into contact with the older Paleozoics, but toward the east these faults diminish and die out. This area, although by no means synclinal in structure, has been referred to as the Franks syncline* and, together with the region immediately around the town of Franks, is to be considered as the type area for the Franks conglomerate. Individual beds outcropping in the vicinity of Franks have been followed entirely across the so-called syncline so that there is no doubt that the true Franks occupies all the western portion of the triangular area here described. Toward the east, however, conditions are more complex. Beds followed eastward from the vicinity of Franks are found to swing northward and then double back westward along the northern limb of a very narrow syncline. If followed still farther they are found to continue westward for a short distance, then to swing northward again and finally to bend northeastward around the end of a broad westward plunging anticline which represents the principal structural feature of the so-called Franks syncline. Lower and lower beds are thus exposed as one travels eastward.

About one-half mile southwest of Franks, beds belonging to the upper portion of the Franks conglomerate are in faulted contact with the Hunton and Woodford formations. As already stated this fault dies out toward the east, so that in the eastern part of sec. 35, T. 2 N., R. 6 E., it lies within the Franks (that is, upper Franks is in contact with lower Franks); two miles farther east no faulting has been observed. In section 35, where the displacement diminishes so that the Franks conglomerate is present to the south of the fault, this formation is found to rest upon the Caney shale. On first examination the contact between the two formations appears to be one of conformity, but careful investigation discloses the fact that at most places the Caney shale is more highly folded than the Franks. If this contact is followed eastward lower and lower beds of the Franks are found in contact with the Caney and in sec. 6, T. 1 N., R. 7 E., a thin outcrop of Wapanucka, with its typical fauna, makes its appearance above the Caney. The point at which the Wapanucka first appears is very critical, but rock exposures there do not permit direct observation of the true relation of the strata, and evidence regarding this relationship must be secured from another source. Fortunately such a source is available.

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*Reeds, Chester A., Okla. Geol. Survey, Bull. 3, p. 49, 1910.

In the west central part of sec. 6, T. 1 N., R. 7 E., a thin red limestone which carries a characteristic fauna is exposed in the basal beds of the Franks conglomerate. At the point just mentioned this stratum is about 465 feet above the Caney shale. The information to be gained by a thorough understanding of the stratigraphic position of such a key bed is of such importance that a very careful survey of its outcrop was made toward the east. Although there were short distances where it was so poorly exposed that the outcrop could not actually be followed by walking, the character, fauna, relations of overlying strata and the alignment of the exposed portions permits little doubt as to their identity.

Here, then, is the solution of the relationship between the Franks conglomerate and the Wapanucka limestone. Near the eastern edge of the Stonewall quadrangle the red limestone mentioned is found to rest just 15 feet below the Lehigh coal of the McAlester formation. The identification of this coal bed is based on its position near the top of the McAlester formation and on the presence of a very characteristic fossiliferous stratum, described by Taff, * which rests upon the coal.

A section measured downward from the red limestone at this point shows a thickness of approximately 2,000 feet between it and the top of the Wapanucka limestone, and when it is remembered that in the western part of sec. 6, T. 1 N., R. 7 E. it is only 465 feet above the Caney shale and that the Wapanucka limestone is not there present, it is obvious not only that the formation is to be correlated with the upper part of the McAlester formation, but that it is part of an overlapping series.

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*Taff, J. A., U. S. Geol. Survey Geol. Atlas, Coalgate Folio (No. 74), 1913.

In short, the lower part of the Franks conglomerate is to be correlated with the McAlester shale of Taff; it belongs to a position in the stratigraphic section far above the Wapanucka limestone, and has been erroneously correlated with the latter formation only because of the overlap which brings the upper part of the McAlester into contact with the Wapanucka, and, subsequently, the Caney, near Franks. However, only the lower part of the Franks is to be correlated with the McAlester formation. The upper portion, at least in part, is equivalent to the Savanna sandstone and the Boggy shale. The Franks syncline is so situated that the strata therein cannot be traced definitely into any formation higher than the Boggy, but there is evidence which indicates that some, and possibly all, of the formations between the Boggy and Ada formations may be represented within the syncline. This evidence rests on lithologic and faunal similarity; and as the fossils collected have not yet been fully identified, the writer hesitates to make any definite statement as to whether all or any of the formations above the Boggy are represented within the Franks syncline. In the hope of establishing a clearer understanding, however, it is desired to assume for the moment that some remnant of the true Seminole of Taff is represented within the Franks syncline.

It is to be borne in mind that a correlation of the Franks and Seminole conglomerates has been suggested. Although the authors of this hypothesis started with a conglomerate that is not equivalent to the Franks and correlated it with a conglomerate which is not equivalent to the Seminole, yet, if any remnant of the Seminole is assumed to lie within the Franks syncline, their conclusion as to the correlation of the two formations must be considered to be at least partially correct. In other words, since conglomeratic beds outcropping in the vicinity of Franks have been mapped over the entire area of the Franks syncline, any beds which are assumed to be present within the syncline are automatically assigned to the Franks. It is obvious that such a condition can only lead to confusion. If in addition to such an assumption an attempt is made to include within the Seminole all the conglomeratic strata above that formation, confusion becomes chaos. If the Franks conglomerate is to be thought of as representing the shoreward phase of all Taff's formations above the Hartshorne sandstone; if it includes the Seminole conglomerate; and if, moreover, the Seminole is to be thought of as including all the strata above it, so as to embrace the Pontotoc series, which includes the conglomerates at Sulphur; then all the formations of southern and east central Oklahoma above the Hartshorne sandstone which lie north of the Arbuckle Mountains and the Choctaw fault are to be considered as Franks or Seminole, depending on which of these supposedly synonymous terms are elected for use.

Retention and use of the term Seminole, as defined by Taff, and the entire abolition of the name Franks, probably constitute the most logical remedy for this undesirable state of confusion. To apply this suggestion it would only be necessary to subdivide the strata of the Franks syncline into the several formations which they are thought to represent. It is realized, however, that there are grave difficulties attendant upon any attempt to abandon a term so well established as is the Franks; and, in view of its long use, it will probably be more satisfactory to retain the term Franks, but to retain it with restrictions that have not heretofore been applied. It is the writer's opinion that the term Franks should be restricted to the following Pennsylvanian strata: (1) those occuring in the type area, i. e., near the town of Franks and (2) those exposures of limestone conglomerates (and their immediately associated strata) which occur in the Arbuckle area and which, in common with the strata at Franks, have the three characteristics of being (a) fossiliferous, (b) highly folded and faulted, or both highly folded and faulted, and (c) non-arkosic.

Brief reference should be made to a small area which lies beyond the limits of the Stonewall quadrangle. This is the Mill Creek syncline of the Tishomingo quadrangle, which adjoins the Stonewall quadrangle on the south. The strata within this syncline are largely conglomeratic (although the basal limestones contain but few scattered pebbles) and were assigned by Taff to the Franks conglomerate. If we now return to the criteria used in distinguishing the conglomerates at Franks and Sulphur (see tabular form on page 10), a method is available for determining to which type (Franks or Sulphur) the strata of the Mill Creek syncline belong. The evidence is definite and is not to be denied; for even the most cursory examination of the Mill Creek strata shows that they are: (1) non-arkosic, (2) highly folded and faulted, and (3) very fossiliferous. Of the two possibilities, as to whether they are of Sulphur or Franks type, their characteristics clearly place them in the latter, but, as has been shown, an assignment to the Franks rather than to the Sulphur (Pontotoc) conglomerate means only that the beds are of comparatively early rather than very late Pennsylvanian age.

From a fossil collection taken from beds within the Mil Creek syncline, Moore* identified *Meekella striatacostata*. The writer also found this fossil in the strata there, and althougl the form is generally supposed to indicate somewhat late Pennsylvanian, it seems entirely possible that this supposition is no well founded. *Meekella striatacostata* is a common fossil in the For Scott limestone of Kansas, which formation has been corre-

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*Moore, Raymond C., Am. Asso. Pet. Geol., Vol. 5, No. 1, p. 191.

INTERPRETATION OF THE STRATIGRAPHIC POSITION OF THE FRANKS FORMATION.

Age	Formation	Taff 1903-4	Moore 1921	McCoy 1921	Morgan 1923
CARBONIFEROUS	Pontotoc			SEMINOLE or FRANKS	
	Ada*				
	Vamoosa*				
	Belle City* †				
	Francis*				
	Seminole		FRANKS		
	Holdenville				
	Wewoka				
	Wetumka				
	Calvin				
	Senora				
	Stuart				
	Thurman				
	Boggy				
	Savanna				FRANKS
	McAlester				
	Hartshorne				?
	Atoka				
	Wapanucka	FRANKS			
	Caney				
	Sycamore				
	Woodford				

* New formations to be described in a forthcoming paper.

† Name by Boone Jones (Unpublished Mss.)

lated* with the Calvin sandstone of east central Oklahoma. The Calvin sandstone occurs beneath the Wetumka shale, which lies below the Wewoka formation; and after a very careful study of the Wewoka fauna Girty concluded that it belonged at least as low as mid-Pennsylvanian. Apparently, therefore, *Meekella striatacostata* may be thought of as extending into or below middle Pennsylvanian and could not reasonably be taken to indicate a late Pennsylvanian age for the beds within the Mill Creek area.

In the course of the present investigation several collections were made from the Mill Creek syncline and at the top of the section was found one fossiliferous horizon which is thought to be highly important. This is a "Cup coral" zone such as is described by Goldston** in his discussion of the Glenn formation, and such as occurs 15 feet below the top of the Boggy formation in the Stonewall quadrangle. The writer has never found such a zone within the Stonewall sheet except at the one horizon, and it is for that reason that the Mill Creek occurrence is considered to be of such importance. The principal "Cup coral" occuring within this supposedly contemporaneous zone both in the Stonewall and Mill Creek areas is *Campophyllum torquium*, and in both localities it is very abundant and attains a large size. If the evidence afforded by this zone is as important as it seems, it would appear that the Mill Creek section belongs to the Boggy and possibly older formations. This is in keeping with the correlation which has been suggested for the conglomerates at Franks and Mill Creek, and it also agrees with Taff's early reference of the strata of the Mill Creek syncline to his Franks conglomerate.

In conclusion, then, it may be said that:

1. The conglomerates at Franks and Sulphur are distinctly different in age, the latter belonging to the Pontotoc series.
2. The Pontotoc series, including the conglomerates at Sulphur, occurs several hundred feet above the Seminole conglomerate, and the two are not to be correlated.
3. The Seminole conglomerate, as defined by Taff, is a definite and mappable unit and should be retained as defined.
4. The Franks conglomerate represents the shoreward phase of the McAlester, Savanna, Boggy and possibly younger formations. In no way is it to be regarded as equivalent to the Wapanucka limestone. If the Franks conglomerate is

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*Idem, p. 39, also see Seibenthal, C. E., U. S. Geol. Survey Bull. 340, p. 191.

**Goldston, W. L. Jr., Differentation and structures of the Glenn formation: Am. Asso. Pet. Geol., Vol. 6, No. 1, p. 8.

regarded as containing, near its upper limits, the shoreward phase of beds higher than the Boggy, so that the Seminole conglomerate is included, the suggested correlation of the Franks and Seminole would be partially justified,—but only partly justified because the Seminole could be regarded as representing only a small portion of the Franks. By the same line of reasoning whereby the Seminole might be considered as equivalent to part of the Franks, all of the beds below the Seminole, down to and including the McAlester shale, might be assigned to that formation.

It is therefore suggested: (1) that the term Franks conglomerate be abandoned and that the strata comprising it be divided as nearly as possible into the formations which they represent; or (2) that the term Franks be used only in a restricted sense to apply to the Pennsylvanian strata in the type area around Franks and to those exposures of Pennsylvanian limestone conglomerates in the Arbuckle area which, in common with the strata at Franks, are found to be (a) fossiliferous, (b) highly folded or faulted, and (c) non-arkosic. Of the two suggestions, the first is more logical and, if rigidly applied, would soon end the confusion that now exists in regard to the formation. The second suggestion, however, has in its support the long use of the term Franks. It is a more general term and is, therefore, more easily applied. For these reasons it is probably desirable to preserve the term Franks; but if it is preserved, it must be limited in some manner, as here indicated.

The Strata of the Mill Creek syncline of the Tishomingo quadrangle are to be correlated with the beds at Franks, and are thought to represent the Boggy and possibly older formations.

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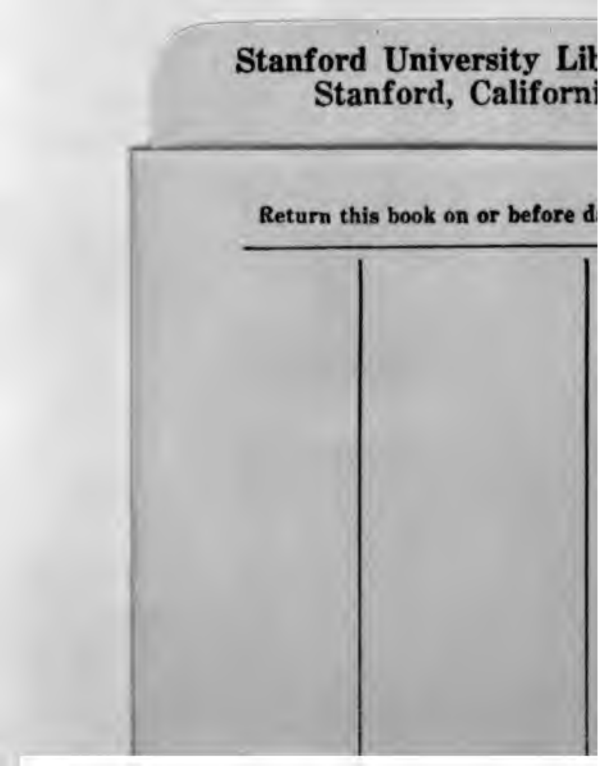

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